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BONE CONDUCTION *

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Those who have been in otologic practice for some years have recently had to adapt themselves to entirely different conceptions of the physiology of hearing. It is now accepted that a true parcusis does not exist. More recently it has been found that the conception held of increased bone conduction is wrong. One cannot say that there is no such thing as an increased bone conduction; further and more extended work is needed on this point. However, patients with fixation of the stapes and chronic catarrhal otitis media who show increased bone conduction in the office do not show it when tested in a sound-proof room. It is now realized that in making such tests one has been testing the degree of noise in the room rather than the cochlea of the patient. It is to be hoped that clearer concepts of paracusis and increased bone conduction will make it possible not to require any special physiology of hearing and that they will come to be explained as conforming to facts of hearing which apply both to the normal and to the pathologic ear.

The present concept of paracusis is that no one hears better in the presence of a noise; however, a "paracusic" person is relatively on a better hearing basis in comparison with a normal person, and he is able to carry on a conversation much better than in talking with a normal person in a quiet place.[1] The principal reason for this is that a person with paracusis is not bothered by the noise and therefore does not elevate the voice, whereas the person with normal hearing is much bothered by the noise and attempts to speak above the level of the noise.

Similarly, it has been found that patients with fixation of the stapes and chronic catarrhal otitis media exhibit greater bone conduction than a normal person when tested in one's office, but do not have a greater bone conduction than the normal person when tested in a quiet place. Therefore, it is evident that it is the masking effect of the noise in the office that gives the apparent increase in the bone conduction, and that this

* Submitted for publication, Oct. 6, 1930.

1. Knudsen, Vern O., and Jones, Isaac H.: Paracusis, Laryngoscope **36**:623, 1926.

"phenomenon," as it used to be considered, is not a consequence of some anomaly or peculiarity of the conductive or perceptive mechanism.

At this point, however, we should mention that our tests did show that there is such a thing as increased bone conduction which cannot be attributable to the masking effect of a noise. In the sound-proof room, if a plug of wax or water occludes the right external canal, the Weber test is noticeably lateralized to the right ear. When the canal is occluded with wax, the acuity of bone conduction of the right ear is increased 10 decibels. At present there is no theory to explain this.

As Pohlman and Kranz [2] have emphasized, a "conductive" person exhibits both of these characteristics of paracusis and increased bone conduction. It would seem that these two newer concepts may be combined; in fact, the whole matter may be summed up in a sentence —in the presence of a noise, the "conductive" is at a relative advantage both as to air conduction and bone conduction.

Through the years, many ingenious explanations have been advanced by otologists and physiologists to explain both paracusis and increased bone conduction. It has been thought that audible or subaudible vibrations of considerable amplitude could so act on the conductive mechanism and so set it into vibration that smaller vibrations of speech could be transmitted to the cochlea. In brief, it has been considered that the coarser vibrations produced by the noise render the conductive mechanism more sensitive. The outstanding surprise to those who have been brought up in the concept of an actual paracusis is that after there have been so many explanations advanced to explain the "phenomenon," one finds that it does not exist. Similarly, as regards "increased" bone conduction, two explanations have been favored: (1) that the vibrations enter directly into the cochlea by a bony route but cannot be transmitted outward through the middle ear because of its conductive defect; (2) that in fixation of the stapes the increased bony overgrowth favors a better transmission into the cochlea by bone conduction. It would seem that one could also regard these explanations as unnecessary, if the problem were simply one of the masking effect of noise. However, as previously mentioned, there is an actual increase of bone conduction, although slight, when one ear is occluded. Therefore, this "phenomenon" cannot be disposed of simply as in the matter of paracusis.

The most helpful recent work that has been done on bone conduction, as related to the present problem, has been presented by Pohlman and

2. Pohlman, A. G., and Kranz, F. W.: Quantitative Tests on Bone and Air Acuity in Paracusis Willisi, Arch. Otolaryng. **3**:136 (Feb.) 1926.

Kranz,[3] Fowler[4] and Hallpike.[5] The conclusions reached by these investigators are, in the main, corroborated by the experimental work here presented. Our present effort has been: (1) to determine the relative bone conduction sensitivity of the normal ear for tones of different pitch, and (2) to compare the measurements for bone conduction made in the office with similar measurements made in a sound-proof room, in both normal and pathologic cases.

In other words, we have attempted to establish first a normal standard for bone conduction for tones of different pitch, and then to measure the bone conduction in pathologic cases in comparison to this normal standard, both in the office and in the sound-proof room.

We were encouraged to undertake the present work because of the facilities provided by the new Acoustical Laboratory at the University of California at Los Angeles. This laboratory contains a number of rooms that are thoroughly insulated against outside noise. The tests were made in the large sound chamber shown in figure 1. This room consists of a double walled construction, each wall consisting of 12 inches (30.48 cm.) of reinforced concrete. The two walls are completely separated by an intervening air space of 12 inches. In other words, the sound chamber is a room built inside of another room. The inner room is mounted on 6 inches (15.24 cm.) of dry sand and 2 inches (12.7 cm.) of cork, which prevent ground or building vibrations from reaching the sound chamber.

RELATIVE BONE CONDUCTION SENSITIVITY OF THE NORMAL EAR FOR TONES OF DIFFERENT PITCH

It is possible to measure bone conduction either with tuning forks or with special types of bone conduction receivers actuated with alternating current from a vacuum tube oscillator. Measurements made with

3. Pohlman, A. G., and Kranz, F. W.: The Problem of Middle Ear Mechanics, Ann. Otol., Rhin. & Laryng. **34**:1224, 1925; The Influence of Partial and Complete Occlusion of the External Auditory Canals on Air and Bone Transmitted Sound, ibid. **35**:113, 1926; Quantitative Tests on Bone and Air Acuity in Paracusis Willisi, Arch. Otolaryng. **3**:136 (Feb.) 1926; Is a Differential Diagnosis Between Middle and Internal Ear Deafness Possible? Laryngoscope **36**:289, 1926; Monaural Tests on Bone Acuity Under Various Conditions, with Some General Comments on Bone Acuity, Ann. Otol., Rhin. & Laryng. **35**:632, 1926; Observations on Hearing-Acuity for Bone-Transmitted Sound, Proc. Soc. Exper. Biol. & Med. **24**:456, 1927.

4. Fowler, Edmund: Fundamentals of Bone-Conduction, Arch. Otolaryng. **2**:529 (Dec.) 1925; Limitations of Functional Tests in Differential Diagnosis in Deafness, Ann. Otol., Rhin. & Laryng. **38**:766, 1929.

5. Hallpike: Some Observations on Bone Conduction, J. Laryng. & Otol. **45**:1, 1930.

tuning forks are limited to rather low frequencies, since the damping of high frequency forks is so great that their tones become inaudible before or shortly after these forks are placed on the skull. Since the vibrations of the bone conduction receiver are maintained at a definite amplitude, and the amplitude of vibration can be varied by an ordinary volume control, such as is used in audiometric measurements, such

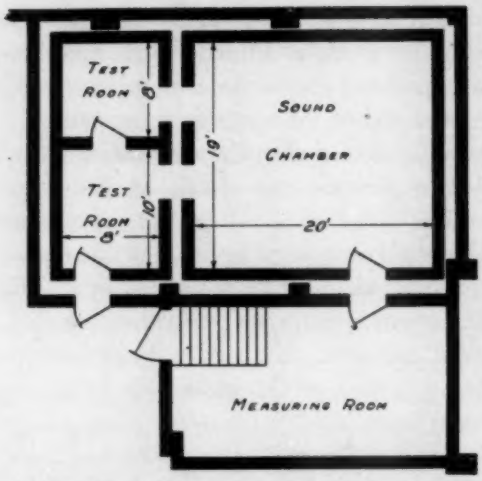


Fig. 1.—Plan of Acoustical Laboratory at the University of California at Los Angeles, showing the double wall construction.

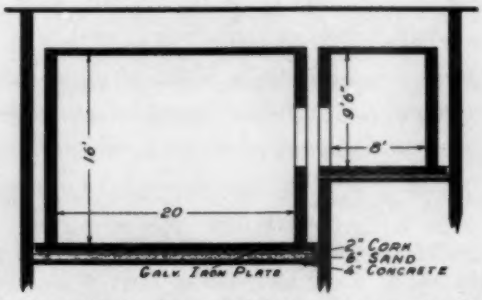


Fig. 2.—Section through the Acoustical Laboratory at the University of California at Los Angeles, showing how the sound chamber is insulated from the ground and the main structure of the Physics Building.

an instrument is satisfactory for quantitative measurements. One can maintain a tone of any desired pitch and loudness. In the present work, we have used the bone conduction receiver which was developed for the audioamplifier.[6] This special bone conduction receiver is a simple modifi-

6. Jones, I. H., and Knudsen, V. O.: Laryngoscope **34**:673, 1924.

cation of a commercial telephone receiver. The ordinary circular diaphragm of the telephone receiver is replaced by a narrow strip of magnetic steel, which is placed directly across the poles of the receiver. This narrow strip greatly reduces the amount of sound energy radiated to the air. Attached to the center of this strip is an aluminum rod 6 inches long. The forced vibration of the steel strip is thus communicated to the aluminum rod, the distal end of which is pressed firmly against the head. The steel strip is so stiff that ordinary pressures applied to it by means of holding the rod against the head do not alter appreciably its degree of vibration.

The sensitivity of hearing by bone conduction was measured by determining the amount of vibration of the aluminum rod when the bone-transmitted sound has been reduced to the threshold of audibility.

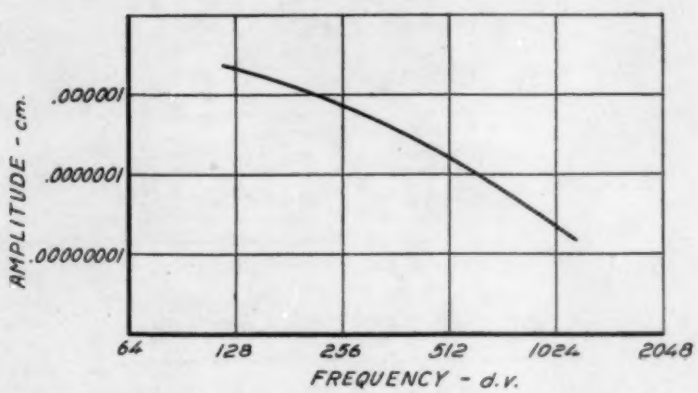


Fig. 3.—Curves showing the amplitude of vibration of the rod in the bone conduction receiver at the minimal threshold, for the normal. The amplitude of vibration is plotted vertically and the frequency of the tone horizontally.

Such measurements of sensitivity were made for frequencies of 64, 128, 256, 512, 1,024, 2,048 and 4,096 double vibrations. The bone conduction sensitivity which we have used for the normal in this series of tests was obtained from measurements on twelve ears that exhibited normal hearing by air conduction.

It would be desirable to express the results of these measurements of bone conduction in absolute units, as is commonly done in the measurement of air conduction. However, by present methods it does not seem possible to make such absolute measurements of bone conduction. Nevertheless, it is possible to measure the amplitude of vibration of the aluminum rod held against the mastoid, and thus determine the amplitude of vibration required barely to elicit the sensation of hearing.

Bone conduction can readily be measured in a sound-proof room for frequencies between 64 and 4,096 double vibrations. This is accomplished by adjusting the volume control of the bone conduction receiver until the tone becomes barely audible. The readings on the dial at the minimal threshold are regarded as the normal. It is then possible to compare the readings of those with impaired hearing acuity with this normal. Although these measurements of bone conduction may be extended as high as 4,096 double vibrations, or even higher in a sound-proof room, we found that it was not possible with the apparatus avail-

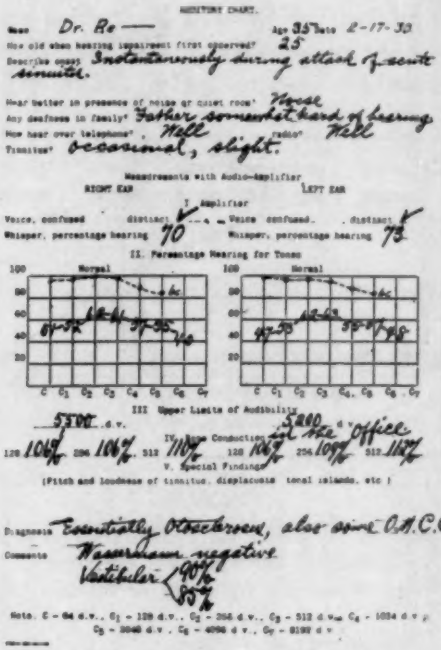

HEARING CHART.
Name Dr. Re ——
Age 35 Date 2-17-33
How old when hearing impairment first observed? 25
Describe onset Spontaneously during attack of acute sinusitis.
Hear better in presence of noise or quiet room? Normal
Any deafness in family? Father somewhat hard of hearing.
How hear over telephone? Well Radio? Well
Tinnitus? Occasional, slight.
Measurements with Audio-Amplifier
RIGHT EAR
LEFT EAR
I Amplifier
Voice, confused distinct 6 Voice confused. distinct 6
Whisper, percentage hearing 70 Whisper, percentage hearing 75
II. Percentage Hearing for Tones
Normal
III Upper Limits of Audibility
5300 d.v.
5200 d.v.
Office
IV Bone Conduction
V. Special Findings
(Pitch and loudness of tinnitus, displacusis tonal islands, etc.)
Diagnosis Essentially Otosclerosis, also some O.M.C.C.
Comments Wasserman negative
Vestibular 90%
85%
Note. C - 64 d.v., C1 - 128 d.v., C2 - 256 d.v., C3 - 512 d.v., C4 - 1024 d.v.,
C5 - 2048 d.v., C6 - 4096 d.v., C7 - 8192 d.v.

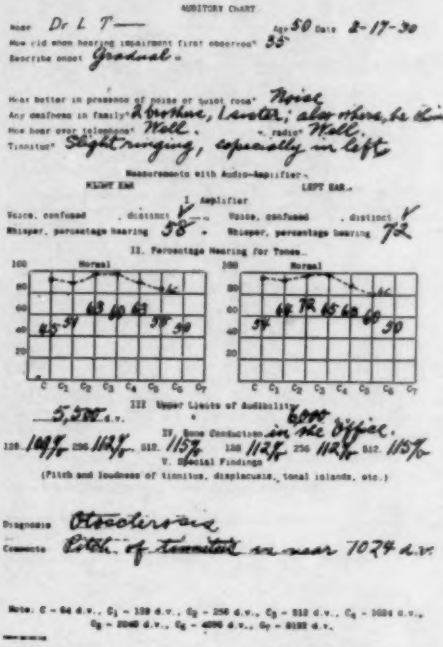
Fig. 4.—Chart for Dr. Re.

able to make precise measurements of the amplitude of vibration of the rod above 1,024 double vibrations. In brief, the minimal threshold for bone conduction can readily be tested as high as 4,096 double vibrations, but the amplitude of the rod was not obtained above 1,024 double vibrations.

The amplitude of vibration at the minimal threshold is extremely small. It required a great amplification of this vibration in order to make it measurable. This magnification of the vibration was accomplished by means of a method similar to that devised by Anderson.[7]

7. Anderson: J. Optic Soc., America, July, 1925.

The aluminum rod of the bone conduction receiver is made to rest lightly on a small cylindric bearing taken from the movement of a watch. As the rod vibrates back and forth, it rocks the small cylindric bearing. A small concave mirror (less than 1 mm. in diameter) was attached to the cylindric bearing. The light from a small straight filament lamp is placed near this small mirror, and the reflected light is focused on a graduated screen of translucent glass. Then as the aluminum rod of the receiver vibrates longitudinally, the image of the straight filament lamp is spread out on the screen, in an amount proportional to the


AUDITORY CHART

Name Dr L T—— Age 50 Date 2-17-30

How old when hearing impairment first observed? 35

Describe onset Gradual

Hear better in presence of noise or quiet room? Noise

Any deafness in family? Brother, Uncle; also where he lived.

How hear over telephone? Well. " radio? Well.

Tinnitus? Slight ringing, especially in left

Headphones with Audio-Amplifier.

RIGHT EAR LEFT EAR

I. Amplifier

Voice, confused . distinct ✓ Voice, confused . distinct ✓

Whisper, percentage hearing 58 Whisper, percentage hearing 72

II. Percentage Hearing for Tones.

Normal Normal

III Upper Limits of Audibility

5,500 d.v. 6000 in the office.

IV Bone Conduction

128 112% 256 112% 512 115% 128 112% 256 112% 512 115%

V. Special Findings

(Pitch and loudness of tinnitus, displacusis, tonal islands, etc.)

Diagnosis Otosclerosis

Comments Pitch of tinnitus at near 7074 d.v.

Note. C_0 = 64 d.v., C_1 = 128 d.v., C_2 = 256 d.v., C_3 = 512 d.v., C_4 = 1024 d.v., C_5 = 2048 d.v., C_6 = 4096 d.v., C_7 = 8192 d.v.

Fig. 5.—Chart for Dr. L. T.

amplitude of vibration of the rod. The optical-mechanical system was arranged in such a manner that the amplification of the motion of the rod was slightly more than one thousand fold. Even with this large magnification, it was not possible to obtain an appreciable reading on the glass screen at the minimal threshold of audibility. Accordingly, the amplitude of vibration of the rod was increased above the minimal threshold by a known amount—an amount which could be measured on the glass screen. Thus, by knowing to what extent the amplitude of vibration had been increased above the minimal threshold, it was possible to calculate the amplitude of vibration at the minimal threshold.

AUDITORY CHART.

Name Mrs. So —— Age 33 Date 3-18-39.

How old when hearing impairment first observed? 33 (Left ear)

Describe onset Stated right ear hearing involved only two months ago. Two years ago, after using telephone, noticed she heard better with right ear.

Hear better in presence of noise or quiet room? Noise

Any deafness in family? None

How hear over telephone? Not well radio?

Tinnitus? Noises seem localized in top of head.

Measurements with Audio-Amplifier.

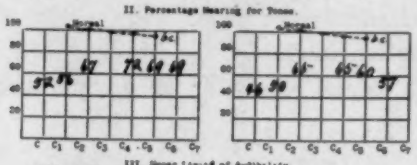
RIGHT EAR. LEFT EAR

I Amplifier.

Voice, confused ✓, distinct Voice, confused ✓, distinct

Whisper, percentage hearing Whisper, percentage hearing

II. Percentage Hearing for Tones.



III. Upper Limit of Audibility

15,300 d.v. 15,000 d.v.

IV. Bone Conduction, in the Office.

128 99% 256 100% 512 102% 128 94% 256 108% 512 109%

V Special Findings

(Pitch and loudness of tinnitus, displacusis, tonal islands, etc.)

Diagnosis Otosclerosis.

Comments Vestibular < 10% Hyperactive
< 10% Hyperactive.
Compress oscillator with electric stapedius along normal contour and mobility of drum membrane, and hammer-handles.

Note. C - 64 d.v. , C_1 - 128 d.v. , C_2 - 256 d.v., C_3 - 512 d.v., C_4 - 1024 d.v., C_5 - 2048 d.v. , C_6 - 4096 d.v. , C_7 - 8192 d.v.

Fig. 6.—Chart for Mrs. So.

AUDITORY CHART.

Name Miss M. Bra —— Age 22 Date 2-19-32

How old when hearing impairment first observed? 16

Describe onset Gradual

Hear better in presence of noise or quiet room? Noise.

Any deafness in family? Brothers deafness came on some way.

How hear over telephone? ... radio?

Tinnitus? Came on coincident with hearing impairment.

Measurements with Audio-Amplifier.

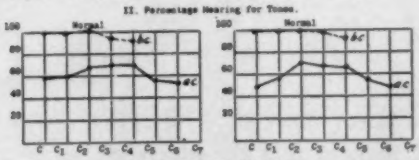
RIGHT EAR. LEFT EAR.

I. Amplifier.

Voice, confused ✓ distinct —— Voice, confused distinct.

Whisper, percentage hearing Whisper, percentage hearing

II. Percentage Hearing for Tones.



III Upper Limits of Audibility

12 000 d.v. 13000 d.v.

IV Bone Conduction, in the Office.

128 103% 256 105% 512 106% 128 91% 256 94% 512 97%

V Special Findings

(Pitch and loudness of tinnitus, displacusis, tonal islands, etc.)

Diagnosis Otosclerosis invading internal ears.

Comments Compress oscillator with electric stapedius along normal mobility and contour, including ... O.M.C.C.

Vestibular < 20% 25%

Note C - 64 d.v., C_1 - 128 d.v., C_2 - 256 d.v., C_3 - 512 d.v., C_4 - 1024 d.v., C_5 - 2048 d.v., C_6 - 4096 d.v., C_7 - 8192 d.v.

Fig. 7.—Chart for Miss M. Bra.

The results of the measurements on the minimal threshold by bone conduction, for the normal, are presented in figure 3. In the curve in figure 3, the vertical axis represents the amplitude of vibration of the aluminum rod required barely to elicit the sensation of hearing, and the horizontal axis represents the frequency of the test tone. It will be noted that the amplitude of vibration which must be communicated to the mastoid bone, in order that the tone be audible, is very small, varying from slightly more than 0.0000015 cm. at 128 double vibrations to 0.000000027 cm. at 1,024 double vibrations, i. e., as the frequency increases the amplitude (and also the energy) of vibration decreases.

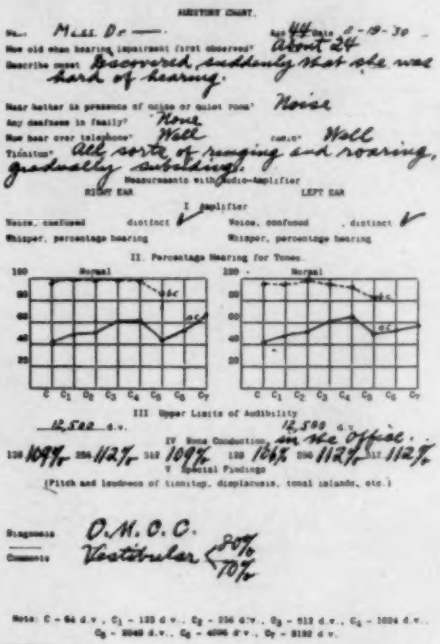


Fig. 8.—Chart for Miss Dr.

It is rather difficult to determine to what extent these amplitudes of vibration will be reduced by the time they reach the cochlea, since this depends on the transmitting properties of the skull and all possible connections between the skull and the interior of the cochlea. However, it is to be expected that there would be an appreciable reduction in the amplitude of vibration as a result of the transmission to the cochlea. This is borne out by comparing these observed amplitudes of vibration with the corresponding amplitudes of vibration of the drum membrane for hearing by air conduction. The corresponding amplitudes of vibration of the drum membrane, at the minimal threshold for air conduction,

are of the order of one one-hundredth of the observed amplitudes of vibration of the aluminum rod in the measurements of bone conduction. In other words, in order to communicate sound to the cochlea by means of a bone conduction receiver making contact with the mastoid process, it is necessary that the amplitude of vibration communicated to the skull must be about one hundred times greater than that which would be communicated to the drum membrane of a normal person by air conduction.

The usual test for bone conduction with the tuning forks might lead to a misconception. The low pitched forks are heard so much more

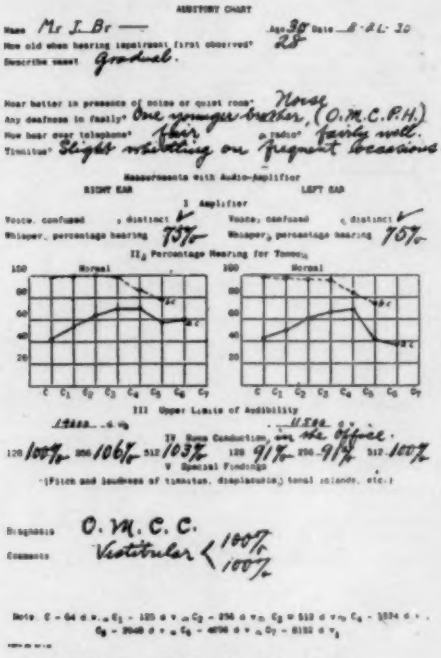

AUDITORY CHART
Name Mr J. Br —
Age 30 Date 8-21-30
How old when hearing impairment first observed? 28
Describe onset Gradual.
Hear better in presence of noise or quiet room? Noisy
Any deafness in family? One younger brother, (O.M.C.P.H.)
How hear over telephone? Fair, radio? Fairly well.
Tinnitus? Slight whistling on frequent occasions.
Measurements with Audio-Amplifier
RIGHT EAR
LEFT EAR
I Amplifier
Voice, confused distinct
Whisper, percentage hearing 75%
Voice, confused distinct
Whisper, percentage hearing 70%
II Percentage Hearing for Tones
Normal
III Upper Limits of Audibility
IV Bone Conduction, see the Office.
128 100% 256 106% 512 103%
128 91% 256 91% 512 100%
V Special Findings
Diagnosis O. M. C. C.
Comments Vestibular < 100% 100%

Fig. 9.—Chart for Mr. J. Br.

readily than the high pitched forks. This might be wrongly interpreted to signify that less energy is required for the low frequencies. The foregoing measurements, however, show exactly the opposite—that the higher frequencies require less energy. The obvious fallacy is attributed to the tuning fork itself. A tuning fork because of its inherent damping is an inadequate instrument for testing bone conduction, especially at high frequencies, where the damping is greatest.

It is a matter of considerable interest to compare the pitch variation of the ear to bone conducted and air conducted sound. Thus if the shape of the curve in figure 3 is compared with the corresponding shape of the

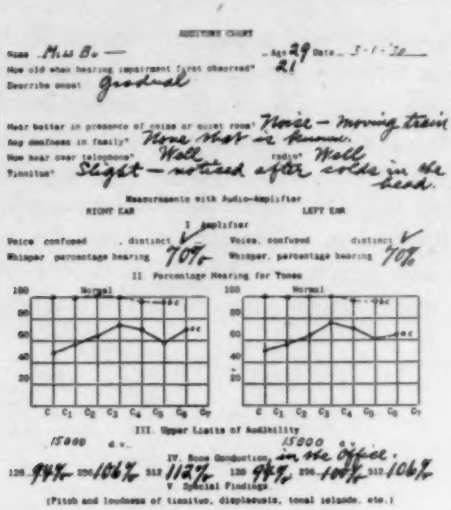

AUDITORY CHART
Name Miss Bu — Age 29 Date 3-1-30
How old when hearing impairment first observed? 21
Describe onset Gradual
Hear better in presence of noise or quiet room? Noise — moving train.
Any deafness in family? None that is known.
How hear over telephone? Well radio? Well
Tinnitus? Slight — noticed after colds in the head.
Measurements with Audio-Amplifier
RIGHT EAR LEFT EAR
I Amplifier
Voice confused . distinct ✓ Voice, confused distinct ✓
Whisper percentage hearing 70% Whisper, percentage hearing 70%
II Percentage Hearing for Tones
Normal
C C1 C2 C3 C4 C5 C6 C7
III. Upper Limits of Audibility
15000 d.v. 15000 d.v.
IV Bone Conduction in the Office.
128 94% 256 106% 512 112% 128 94% 256 104% 512 106%
V Special Findings
(Pitch and loudness of tinnitus, displacusis, tonal islands, etc.)
Diagnosis O. M. C. C.
Comments Vestibular < 85% 75%
Note: C – 64 d.v., C1 – 128 d.v., C2 – 256 d.v., C3 – 512 d.v., C4 – 1024 d.v.,
C5 – 2048 d.v., C6 – 4096 d.v., C7 – 8192 d.v.

Fig. 10.—Chart for Miss Bu.

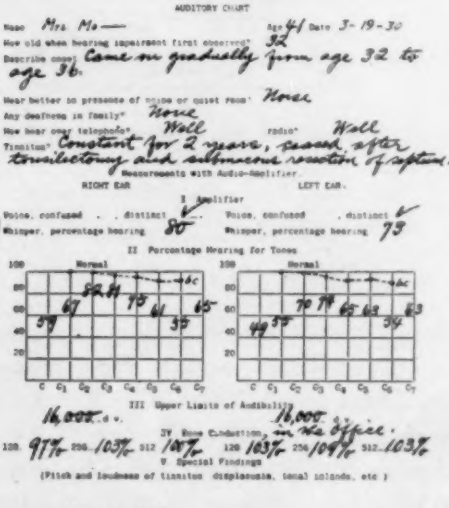

AUDITORY CHART
Name Mrs Mo — Age 41 Date 3-19-30
How old when hearing impairment first observed? 32
Describe onset Came on gradually from age 32 to age 36.
Hear better in presence of noise or quiet room? Noise
Any deafness in family? None
How hear over telephone? Well radio? Well
Tinnitus? Constant for 2 years, ceased after tonsilectomy and submucous resection of septum.
Measurements with Audio-Amplifier
RIGHT EAR LEFT EAR
I Amplifier
Voice, confused . . distinct ✓ Voice, confused . distinct ✓
Whisper, percentage hearing 80 Whisper, percentage hearing 73
II Percentage Hearing for Tones
Normal
C C1 C2 C3 C4 C5 C6 C7
III Upper Limits of Audibility
16,000 d.v. 16,000 d.v.
IV Bone Conduction in the Office.
128 97% 256 103% 512 107% 128 103% 256 104% 512 103%
V Special Findings
(Pitch and loudness of tinnitus displacusis, tonal islands, etc.)
Diagnosis O. M. C. C.
Comments Vestibular < 100% 100%
The progress of the deafness as well as the tinnitus, ceased after operation on the ear and septum
Note: C – 64 d.v., C1 – 128 d.v., C2 – 256 d.v., C3 – 512 d.v., C4 – 1024 d.v.,
C5 – 2048 d.v., C6 – 4096 d.v., C7 – 8192 d.v.

Fig. 11.—Chart for Mrs. Mo.

curve in the Fletcher-Wegel curve for hearing by air conduction, it will be noted that both for air conduction and for bone conduction the sensitivity increases from 128 to 1,024 double vibrations in about the same proportion. For example, the amplitude of vibration at 128 double vibrations, for both air conduction and bone conduction is about fifty times larger than the corresponding amplitude at 1,024 double vibrations. It appears therefore that at least for this limited range of frequencies, namely, from 128 to 1,024 double vibrations, that the variation in the sensitivity by bone conduction is analogous to the varia-

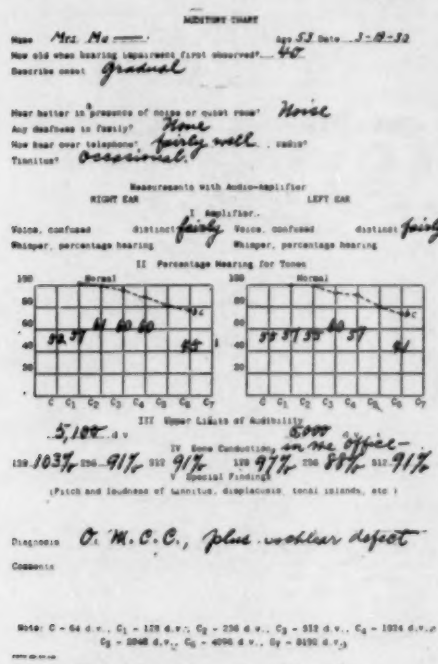
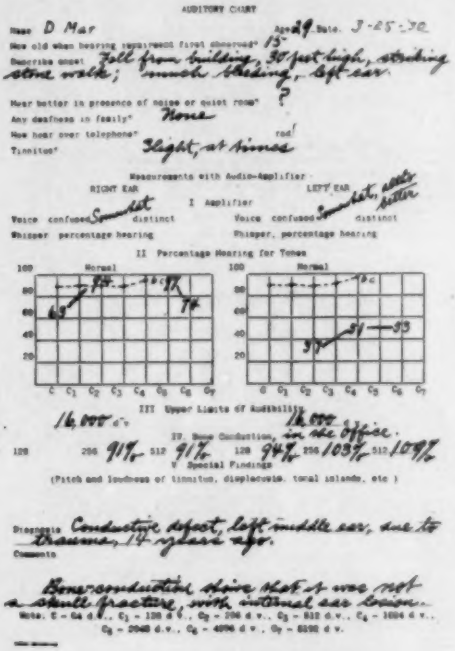

AUDITORY CHART
Name Mrs. Mu ——
Age 53 Date 3-8-32
How old when hearing impairment first observed? 46
Describe onset gradual
Hear better in presence of noise or quiet room? Noise
Any deafness in family? None
How hear over telephone? fairly well
Tinnitus? Occasional
Measurements with Audio-Amplifier
RIGHT EAR
LEFT EAR
I. Amplifier.
Voice, confused distinct fairly
Voice, confused distinct fairly
Whisper, percentage hearing
Whisper, percentage hearing
II Percentage Hearing for Tones
Normal
Normal
C C1 C2 C3 C4 C5 C6 C7
III Upper Limits of Audibility
5,100 d v
8000 d v
IV. Bone Conduction
128 103% 256 91% 512 91% 128 97% 256 88% 512 91%
Special Findings
(Pitch and loudness of tinnitus, diplacusis, tonal islands, etc.)
Diagnosis O. M. C. C., plus cochlear defect
Comments
Note: C = 64 d.v., C1 = 128 d.v., C2 = 256 d.v., C3 = 512 d.v., C4 = 1024 d.v., C5 = 2048 d.v., C6 = 4096 d.v., C7 = 8192 d.v.

Fig. 12.—Chart for Mrs. Mu.

tion in the sensitivity by air conduction. Since the sensitivity of the ear seems to vary in about the same manner for bone conducted sound as it does for air conducted sound, it would seem that the variation in the sensitivity of hearing is primarily a function of the properties of the cochlea rather than the mechanical properties of the conducting mechanism. (There is, to be sure, some variation in the transmission efficiency of the middle ear for tones of different frequencies, but these variations are apparently very much smaller than the variations of the sensitiveness of the cochlea.) At different frequencies one would not expect any marked variation of the transmitting efficiency of either the normal air conduction route or through the normal bone conduction route. For

this reason one would expect this general parallelism between the sensitivity by bone conduction and by air conduction.

On the other hand, as regards the absolute sensitivity of hearing, one would expect a marked superiority by air conduction. The conducting mechanism of the middle ear is especially adapted to communicate vibration to the cochlea, whereas by bone conduction only a small portion of the energy communicated to the skull ultimately reaches the cochlea. Therefore the bony route is relatively inefficient. The differences in these two routes of transmission to the cochlea are sufficient to account


AUDITORY CHART

Name D Mar Age 29 Date J-25-32

How old when hearing impairment first observed? 15

Describe onset Fell from building, 30 feet high, striking stone walk; much bleeding, L ear.

Hear better in presence of noise or quiet room? ?

Any deafness in family? None

How hear over telephone? rod

Tinnitus? Slight, at times

Measurements with Audio-Amplifier

RIGHT EAR — LEFT EAR

I Amplifier

Voice confused Somewhat distinct — Voice confused Somewhat, later better distinct

Whisper percentage hearing — Whisper, percentage hearing

II Percentage Hearing for Tones

Normal — Normal

III Upper Limits of Audibility

16,000 d.v. — 16,000 d.v.

IV Bone Conduction, in the office.

128 256 91% 512 91% — 128 94% 256 103% 512 109%

V Special Findings

(Pitch and loudness of tinnitus, displacusis, tonal islands, etc.)

Diagnosis Conductive defect, left middle ear, due to trauma, 14 years ago.

Comments

Bone conduction shows that it was not a skull fracture, with internal ear lesion.

Note: $C - C_0$ d.v., $C_1 - 128$ d.v., $C_2 - 256$ d.v., $C_3 - 512$ d.v., $C_4 - 1024$ d.v., $C_5 - 2048$ d.v., $C_6 - 4096$ d.v., $C_7 - 8192$ d.v.

Fig. 13.—Chart for D. Mar.

for the observed differences in the sensitivity of hearing by air conduction and by bone conduction.

COMPARISON OF THE MEASUREMENTS OF BONE CONDUCTION IN THE OFFICE AND IN THE SOUND-PROOF ROOM

Two groups of persons were tested, those with normal hearing and those with impaired hearing. The tests on normal persons were conducted to determine the average sensitivity of tones of different pitch. Measurements were made and counted on twelve normal ears (six persons), and the average of these twelve is taken as the normal. This normal is represented by the upper line of 100 per cent in the charts.

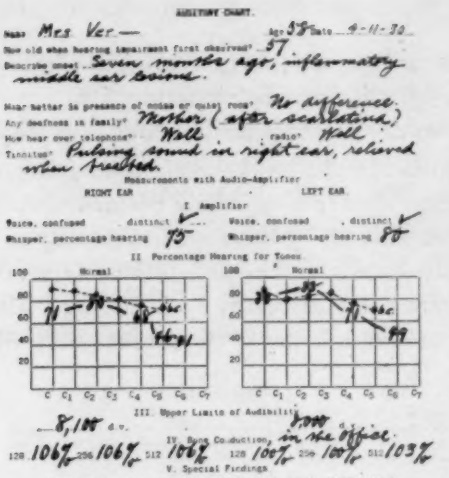

AUDITORY CHART.
Name Mrs Ver—
Age 58 Date 9-11-30
How old when hearing impairment first observed? 57
Describe onset: Seven months ago, inflammatory middle ear boime.
Hear better in presence of noise or quiet room? No difference.
Any deafness in family? Mother (after scarlatina.)
How hear over telephone? Well radio? Well
Tinnitus? Pulsing sound in right ear, relieved when treated.
Measurements with Audio-Amplifier
RIGHT EAR
LEFT EAR
I Amplifier
Voice, confused distinct ✓
Voice, confused distinct ✓
Whisper, percentage hearing 75
Whisper, percentage hearing 80
II Percentage Hearing for Tones
Normal
III Upper Limits of Audibility
8,100 d.v.
IV Bone Conduction, in the office.
128 106% 256 106% 512 106%
128 100% 256 100% 512 103%
V. Special Findings
(Pitch and loudness of tinnitus, diplacusis, tonal islands, etc.)
Diagnosis Cochlear defect, principally. Added to this a recent involvement of both middle ears.
Comment Compred oscillator with electric otoscope shows marked impairment of mobility of both drum-membrane and ossicle, especially the right.
Note: C - 64 d.v., C1 - 128 d.v., C2 - 256 d.v., C3 - 512 d.v., C4 - 1024 d.v., C5 - 2048 d.v., C6 - 4096 d.v., C7 - 8192 d.v.

Fig. 14.—Chart for Mrs. Ver.

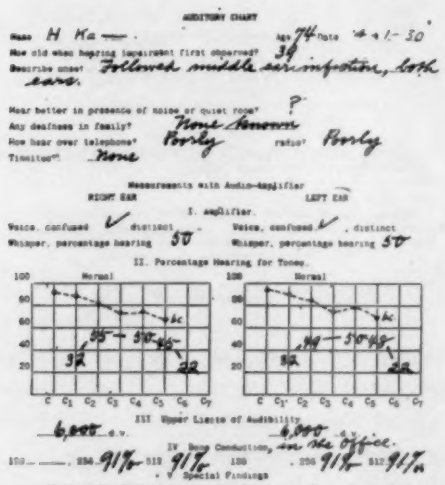

AUDITORY CHART
Name H Ka—
Age 74 Date 9-11-30
How old when hearing impairment first observed? 34
Describe onset: Followed middle ear infection, both ears.
Hear better in presence of noise or quiet room? ?
Any deafness in family? None known
How hear over telephone? Poorly radio? Poorly
Tinnitus? None
Measurements with Audio-Amplifier
RIGHT EAR
LEFT EAR
I. Amplifier.
Voice, confused ✓ distinct
Voice, confused ✓ distinct
Whisper, percentage hearing 50
Whisper, percentage hearing 50
II. Percentage Hearing for Tones.
Normal
III Upper Limits of Audibility
6,000 d.v.
6,000 d.v.
IV Bone Conduction, in the office.
128 256 91% 512 91%
128 256 91% 512 91%
V Special Findings
(Pitch and loudness of tinnitus diplacusis tonal islands, etc.)
Diagnosis O. M. C. P. H., plus cochlear defect.
Comments Vestibular 95%
Note: C - 64 d.v., C1 - 128 d.v., C2 - 256 d.v., C3 - 512 d.v., C4 - 1024 d.v., C5 - 2048 d.v., C6 - 4096 d.v., C7 - 8192 d.v.

Fig. 15.—Chart for H. Ka.

The acuity by bone conduction for normal persons was found to be higher in the sound-proof room than in the office. The readings on the volume control showed that the normal ear exhibits between 12 and 15 per cent better hearing in the sound-proof room. Naturally, this difference is attributable to the masking or "deafening" effect of the noise in the office. This was demonstrated by introducing artifically produced noise into the sound-proof room. A noise of 30 decibels in the room reduced the acuity of bone conduction approximately 15 per cent. This amount of noise—30 decibles—is comparable with the amount of noise in the average office. As the level of the noise was increased, the percentage of hearing by bone conduction was proportionately decreased.

In a tabulated series of 400 pathologic cases, it was found that a considerable number of the patients exhibited "increased" bone conduction

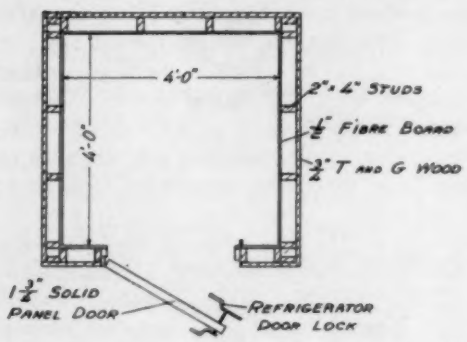


Fig. 16.—Plan of small sound-proof booth for providing a quiet condition for tests of hearing.

when the measurements were made in the office. Twelve patients were selected for tests in the sound-proof room. The ages varied from 22 to 74. All these persons were selected because they were of more than average intelligence and were capable not only of earnest cooperation, but of rendering accurate judgment. The clinical diagnoses in these cases include otosclerosis, four cases; chronic catarrhal otitis media, five cases; trauma of the middle ear, one case; old cochlear defect with recent involvement of the middle ear, one case; chronic purulent hemorrhagic otitis media plus cochlear defect, one case.

REPORT OF CASES

CASE 1 (Dr. Re., fig. 4).—The dotted line in the chart gives the percentage of hearing by bone conduction in the sound-proof room. The measurements made in the office are recorded in "IV., bone conduction," on the charts. In the office, this patient showed an average bone conduction of 108 per cent compared with

the 100 per cent for the person with normal hearing. In the sound-proof room, the bone conduction was approximately normal for frequencies up to 512 double vibrations. Above this frequency, there was a falling off in the acuity by bone conduction, following the corresponding falling off in the acuity by air conduction. Air conduction is represented on the chart by the numbers, each number giving the percentage of hearing at the indicated frequency. The essential observation in this case is that whereas in the office this man showed an "increased" bone conduction, in the sound-proof room it was normal or less than normal.

CASE 2 (Dr. L. T., fig. 5).—The observations are essentially the same as in case 1.

CASE 3 (Mrs. So., fig. 6).—Bone conduction was practically normal throughout the range in both ears.

CASE 4 (Miss M. Bra., fig. 7).—The diagnosis of otosclerosis was confirmed in that on examination the patient's brother presented an almost identical picture.

CASE 5 (Miss Dr., fig. 8).—Although the measurement for bone conduction in the office indicated an average conduction of 110 per cent as compared with that of normal persons tested in the office, the measurements in the sound-proof room showed that the bone conduction was normal or below normal as compared with that of normal persons tested in the sound-proof room.

CASE 6 (J. Br., fig. 9).—The falling off of the bone conduction in the sound-proof room for frequencies above 512 double vibrations would seem to indicate that the cochlea also was involved.

CASE 7 (Miss Bu., fig. 10).—The measurements for bone conduction showed practically no falling off at the higher frequencies, indicating that the hearing defect was entirely conductive.

CASE 8 (Mrs. Mo., fig. 11).—The relatively high bone conduction, even at high frequencies, indicated that there was little involvement of the cochlea.

CASE 9 (Mrs. Mu., fig. 12).—The gradual falling off of hearing for the upper tones by bone conduction in the sound-proof room would seem to indicate that there was a definite cochlear defect associated with the defect of the middle ear.

CASE 10 (D. Mar., fig. 13).—This case presented a rather striking instance of good bone conduction even in the presence of great loss by air conduction in one ear. (However, the good bone conduction in the left ear might have been due to the nearly normal hearing of the right ear.)

CASE 11 (Mrs. Ver., fig. 14).—In this case of "mixed" deafness, in which the cochlear defect was predominant, it was of interest to note that the measurements for bone conduction in the sound-proof room almost paralleled those for air conduction. This was particularly true for the left ear. The measurement for bone conduction in the office would have led to the conclusion that the defect was largely conductive, whereas the measurements in the sound-proof room corrected this diagnosis—an error because of the noise in the office.

CASE 12 (H. Ka., fig. 12).—Although a marked cochlear defect was evidenced by the impaired bone conduction, there was a wide divergence between air conduction and bone conduction, for the low frequencies, thus demonstrating a marked conductive defect due to the chronic purulent hemorrhagic otitis media.

The foregoing cases suggest:

1. Increased bone conduction was not actually present in these cases. In the sound-proof room, none of the markedly conductive

persons showed a greater bone conduction than normal persons. This confirms the evidence presented by Pohlman and Kranz, and Hallpike. However, as already mentioned, this evidence does not signify that increased bone conduction never exists. It does indicate, however, that cases of this type, with which we have always associated increased bone conduction, do not show this increased conduction.

2. Charting the percentage of hearing by bone conduction on the same chart with the air conduction, as suggested by Fowler, is advantageous in making the diagnosis.

3. Quantitative measurement of bone conduction throughout a wide range of frequencies facilitates differential diagnosis, making it possible to estimate the degree to which either the conductive or the perceptive lesion has contributed to the defect in hearing.

4. It is advantageous to test hearing in a sound-proof room.

CONSTRUCTION OF SOUND-PROOF BOOTH

We have constructed a sound-proof booth that can easily be erected in any office of average size at a cost of about $100. The plan of construction is shown in figure 16. It is 7 feet (215.4 cm.) high, and has outside floor dimensions of 4 by 4 feet (121.9 cm.). The framework is of 2 by 4 wooden studs. The outside of these studs may be covered with either ½ inch (1.27 cm.) plaster-board or ¾ inch (1.9 cm.) tongue and grooved wood. The inside is completely lined with ½ inch fiber board, such as Celotex, Insulite or Masonite. The door may be made of a 1¾ inch (3.9 cm.) solid panel, and should be provided with two refrigerator locks which tighten the door against rubber strips at all points of contact. This booth adequately shuts out the noise encountered in the average office. Tests made in such a booth compare favorably with tests made in elaborate sound-proof rooms. It is naturally advisable to locate this booth in a quiet part of the office. If the building is subject to severe vibration, such as the vibration from elevators, it is necessary to place 2 inch (5 cm.) pads of rubber, 6 by 6 inches (15.2 cm.), under each corner of the booth. The isolation against noise provided by such a booth provides for the tests of hearing, a condition analogous to the dark room in which the ophthalmologist makes his tests of vision.

CHRONIC MAXILLARY SINUSITIS

AN ANALYSIS OF ONE HUNDRED AND NINETY-TWO CASES THAT CAME TO OPERATION *

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QUINCY, ILL.

Rhinologic patients tend to become pessimistic, and are prone to take the fatalistic attitude that "once a sinus, always a sinus." My personal impression that this condition of affairs does not actually exist, especially in disease of the maxillary sinus, has led to a careful analysis of 192 cases of chronic maxillary sinusitis which finally came to operation. No attempt has been made to include in this report the results in other diseases of the sinus, nor has there been an effort to give the final outcome in cases of chronic maxillary disease in which the patients were treated by conservative methods. I do not operate in every case of chronic infection of the sinus, and a great many of my patients have recovered without operative procedures.

All of these cases occurred in private practice, among a clientele such as one finds in an average small community of the central Mississippi valley. G. L. Reid and H. Neivert considered this the most reliable source of data, and they said that data from large charity clinics and postmortem rooms are selected by circumstance. Undoubtedly, too, data from various rhinologists would vary according to the geographic location and the type of practice.

Hesitation to follow well considered advice is undoubtedly due to the prevailing popular impression that little can be accomplished by operation on the sinuses, and that, too often, one operation is followed by many others with little or no amelioration of symptoms. Because there may be some foundation for the present point of view of the layman regarding diseases of the sinuses, one should pause and take stock of present knowledge. Reflected from the recent rhinologic literature is an air of pessimism, if not an expression of helplessness, in the treatment for diseases of the sinuses in general.

Proetz, in an article filled with doubts as to knowledge of the real situation, stated: "We know also that from a shocking percentage of sinus operations, no relief is obtained, in fact the operation often aggravates the symptoms or produces new ones." Those in general practice

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have somehow also sensed the situation. This is not to be wondered at, for too often I am confronted by physicians who feel that little, if any, relief can be obtained by surgical intervention in disease of the sinuses, and if the truth is admitted their attitude is partially justified. To have referred a trusting patient for nasal consultation, only to learn that he has drifted from one rhinologist to many others, in each instance being subjected to operation, does not create good favor, particularly when the patient returns and in despair asks, "what next?"

Lewis was conscious of considerable doubt and dissatisfaction concerning much of the surgical intervention in common inflammatory involvement of the sinuses. "Respecting radical surgery there remains nothing desirable; it offers little or nothing of ultimate value to the patient."

The literature dealing with the sinuses is markedly voluminous, "about 150-200 articles being published yearly" (Smyth). This signifies present interest in the subject and reflects the tremendous efforts being made by rhinologists throughout the world to extend knowledge and to develop more certain control of this problem.

While no attempt has been made to include other than chronic cases which finally came to operation, in going over all of my records this analysis seems to confirm what has been my personal opinion regarding maxillary disease; namely, that in most acute cases the patients recover spontaneously or with conservative types of treatment. No attempt has been made to include maxillary disease associated with other infections of the sinus. However, I have had many cases of pansinusitis in which the maxillary sinus was also involved. Many patients with chronic maxillary sinusitis were seen and treated without operation. These are not included in this report. Neither have acute or subacute cases been considered.

Classification has been made with reference to:

Sex
Age
Incidence
The probable duration and cause
The chief complaint for which the patient came for treatment
Whether or not focal disease was present
The relation to dental disease
Observations as to transillumination, the roentgen ray and puncture
The type of treatment instituted before operation was decided on
The type of operation performed
Gross observations at operation
Subsequent treatment, with its length of convalescence
Whether or not there were associated conditions in the nose and throat
The end-result of the local and focal disease

Bacteriologic and pathologic observations are given only in selected cases, because but few of these examinations were made. This is easy to understand, for in private practice little or nothing is gained by the patient from these examinations, and considerable expense is added thereby.

AGE, SEX, INCIDENCE

There are 95 males and 97 females. The average age at the time of operation was 35 years, the youngest patient being 3 years, the oldest, 67. The average age of the females was 36, of the males, 33. The histories in 13,620 cases of involvement of the ear, nose and throat were reviewed in locating these records. The left maxillary sinus was affected in 68 cases, the right in 66. It has been said that posture during sleep is an etiologic factor in the causation of this disease. My small series would indicate that this probably is not so. Bilateral infection was present in 59 cases. Lockard and Argall found unilateral involvement in 152 and bilateral involvement in 203 of 355 cases, a much higher percentage of incidence of bilateral involvement than in my series.

Israel expressed the belief that diseases of all of the nasal sinuses are becoming more frequent and that the maxillary sinus is most frequently invaded because of its size. He said that maxillary disease never originates in the sinus itself as a primary condition, but that the invasion is secondary to acute infections of the upper respiratory tract. He classified maxillary diseases into two types. In the first class are those giving a definite history of nasal pathologic change following an acute attack of influenza or coryza. In the second classification are included the patients who are unaware of the presence of disease of the nasal sinus, other than a slight amount of postnasal discharge, but who often have focal disease. He expressed the opinion that a great many cases in adults are merely a continuation of the same condition contracted in childhood.

The maxillary sinus is undoubtedly more frequently infected than any of the other sinuses. My survey shows its comparative frequency as follows:

Maxillary sinusitis	415
Ethmoid sinusitis	148
Sphenoid sinusitis	22
Frontal sinusitis	63

These figures are for chronic infections.

ETIOLOGY

Whatever interferes with the ventilation and drainage of the sinuses acts as a predisposing cause to sinusitis, such as a deflected septum or an enlarged middle turbinate.

In Fenton's opinion, swimming and diving interfere with the protective apparatus of the nose, destroying the vitality of the cell by osmosis, washing pathogenic organisms into the sinus from the nose and throat and inducing trauma of the ostia of the sinus. Diet and allergy are to be considered as possible systemic factors (Dean).

Thirty-two cases followed the extraction of teeth. In thirty-one cases it was felt that a deflected septum was responsible for the condition. One patient was an inveterate swimmer and diver, and undoubtedly his nasal condition was entirely due to the action of aspirated water. In the remaining cases, no cause could be assigned to the condition. Many of the patients could trace their initial symptoms to a sudden chilling with an attack of acute cold in the head. One case followed an attack of scarlet fever.

The etiology of disease of the sinus still remains an unsolved problem. It is true that many cases present indisputable evidence of insufficient ventilation and drainage due to structural abnormalities in the nasal passages. Deflected septums, anomalous development of cells in the middle turbinates and unusually large inferior turbinates unquestionably predispose to this disease. Yet how often does inspection show an apparently normal nasal cavity in a person suffering from disease of the sinus, while in another patient one is unable to understand how any of the sinuses could be properly drained and ventilated, and yet the patient gives no history of any nasal disease or discomfort? There remains much to be done in experimental investigation regarding the underlying causes, deficiency in calcium, endocrine disturbances, the relation of the disease to metabolic disorders, changes in the blood chemistry from normal, and other factors. All must be predisposing factors. There is something more than contact and exposure to acute infections; the nasal cavities are never free from bacterial content. What makes them more virulent at one time than at another remains a mystery. Pathologic changes seen in tissue removed does not offer a solution of the problem. Suppurative and hyperplastic disease as seen under the microscope does not produce greatly different changes.

SYMPTOMS

The average duration of the complaint for which the patient sought relief was ninety-four days. The chief complaint was frequent attacks of common colds in the head, this being present in 102 cases. Thirty patients in the series complained chiefly of a discharge from the nose and into the postnasal space. Pain was present in 63. The location of the pain was definitely over the anterior wall of the sinus, extending into the upper teeth of the affected side. In a few cases the patient

stated that the teeth seemed too long on that side and that unconsciously they had formed the habit of chewing on the opposite side. Several patients stated that the eye and orbit were sore, and that moving the eyeball was painful. Pain remotely located about the head was not encountered. Subjective odor was present in 5 cases and was most noticeable when the patient stooped over. Six patients complained of severe frontal headache. Nasal obstruction was the dominating symptom in 15 cases. One patient complained of a definite tumor growing into the nasal cavity. This proved to be a cyst which had broken down the naso-antral wall. There were 30 patients who were conscious that their trouble had followed the extraction of diseased teeth. One patient consulted me because of an intense orbital cellulitis, which was secondary to an abscess of the lacrimal gland; investigation proved that both of these conditions followed an acute flare-up of a chronic maxillary disease.

Pond analyzed eighty-five consecutive operations on the antrums. The chief complaint was profuse nasal discharge in fourteen, frontal headache in twelve and nasal obstruction in ten. The other principal reasons for operating were frequent colds, chronic conjunctivitis, rheumatism, cough, vertigo, asthma, malaise and hay-fever.

A number of patients were referred to me by internists in an effort to locate a focus of infection. Of these, two were referred because of a rapid pulse; two because of persistent rise in temperature in the afternoon; one of the latter had been confined in a sanitarium with a diagnosis of pulmonary tuberculosis; later events proved this to be otherwise; two because of chronic bronchitis; one because of bronchiectasis; two because of chronic gastritis, and a number of others because of malnutrition, malaise and vague symptoms of general poor health; one because of recurrent erythema; twelve because of rheumatism in various parts of the body; one because of nerve deafness; one because of ulcer of the cornea; five because of asthma; two because of acute nephritis; one because of herpes ophthalmicus; one because of persistent urticaria, and one because of choroidoretinitis.

Emerson maintained that the varying symptomatology of chronic maxillary disease depends on the pathologic condition present. He recognized four types:

1. "As a result of a catarrhal process. In this type only the surface mucosa is involved and it is greatly thickened. Discharge is persistent, but pain is rare, though a vague discomfort about the orbit may be present. The patient has a markedly increased susceptibility to colds." Sewall, in the ARCHIVES, likewise called attention to the fact that when "so-called colds in the head recur in rapid succession one is dealing with

subacute or chronic disease of the sinus." "The ordinary cold is a self-limited disease, and one attack confers a definite immunity that usually lasts six months."

2. "Chronic maxillary sinusitis as the result of a suppurative process. The secretions may be fetid, mucopurulent or purulent. The patient complains of dry throat, persistent cough and marked pharyngitis with irritation. Pus of the granular type may be washed out, which Ersner remarked is a sign of chronic infection of the sinus. Pathologic examination shows a chronic inflammatory reaction of the mucosa and periosteum with a noticeable increase in fibrous tissue, and thickening of the vessels entering the bone."

3. "With polypoid changes. Discharge is encountered and symptoms are those of a subacute nasopharyngitis." Hirsch maintained that "most of the polyps usually seen in the region of the middle meatus originate in the maxillary sinus." "Swelling and edema of the mucous membrane and dilatation of the maxillary glands are responsible for the greater number of these masses."

4. "Chronic maxillary disease with degenerative changes. Emerson detailed the pathologic changes in this condition in a special article. He found that the lining cavity may look smooth or it may be covered with small multiple abscesses. An isolated polyp may be seen here and there, and the cavity may be filled with serum or a gelatinous mass. The mucosa is found to be loosened in the bowl of the antrum, pus may be found between the mucoperiosteum and the bony wall and an osteitis may be present. Polyps may be of the mucoid type, or may contain a large amount of fibrous tissue. The process is generally diffused, and not circumscribed."

Phillips, in an interesting article, concluded "that the severity of a sinusitis or sinus infection depends on the power of the mucus to prevent its destruction by the inspired micro-organisms and if the property that mucus possesses of preventing the passage of water, and hence the water soluble toxins, is destroyed, a progressively increasing poisoning by the toxins of the ciliated epithelium occurs. As this ciliary paralysis increases in amount the secretion of mucus is also paralyzed, until finally the micro-organisms come to dwell in a symbiotic state in the sinus, and the toxins from them are readily absorbed with the production of remote symptoms." He concluded that he is "thoroughly convinced that a healthy ciliated epithelium is a most important factor in maintaining a normal sinus condition, and our treatment should be directed toward reestablishing this healthy condition in as short a time, and with as little derangement of the cilia, as is possible."

RELATION TO DENTAL DISEASE

Thirty-two of the cases, or about 16 per cent, followed the extraction of teeth. Hempstead found 63 cases among 385 patients with chronic maxillary disease, a percentage of 22.5. Skillern was inclined to accept 20 per cent as the proper proportion, but in reviewing cases that came under his observation it would seem that even this figure was now too high. Divergence of opinion of different observers places the percentage at from 5 to 100 per cent.

The teeth involved were as follows:

First molar tooth alone	8 cases
Second molar tooth alone	4 cases
Third molar tooth alone	4 cases
First bicuspid tooth alone	1 case
Second bicuspid tooth alone	4 cases
Canine tooth alone	1 case
Second bicuspid and first molar	8 cases
All teeth on affected side	8 cases

In seventeen cases there was a persistent fistula leading into the sinus at the site of an extracted tooth. I am not able to state definitely whether or not these fistulas would have occurred from simple extraction, but I have been impressed with the number of patients who, following the extraction of teeth, have had the socket of the tooth curretted widely by dentists who have made no attempt to close the wound.

Personal observation gives the impression that few cases of maxillary infection are due to diseased conditions about the apexes of teeth before extraction has been done. I can recall only two cases that were diagnosed before the extraction of a tooth. What has been more frequently encountered has been antral disease secondary to the extraction of a tooth. I am not prepared to state that dental manipulations have been responsible for secondary infection, nor that in every case secondary infection was avoidable. However, it is a fact that in most of my cases nasal symptoms did immediately follow and did not precede dental surgery.

Brown aptly stated "that in considering the relationship between the teeth and the maxillary sinus we must first think of the relationship between the oral surgeon and the rhinologist. If either is to do his work intelligently he must have a working knowledge of the specialty of the other. This does not mean that the rhinologist may usurp the function of the oral surgeon or that the dentist should undertake to practice rhinology. Each must have a clear idea of the limitations of his own field." The day of maxillary drainage through the alveolar process has long since passed. Dentists should recognize the fact that serious, chronic complications will almost invariably ensue if curettage

is so done that a large hole is broken through the process into the maxillary sinus. The difficulty of eradicating such a fistula is very great. Small fistulas respond readily to treatment. Large openings present a complicated problem, even though drainage is established in the nose counter to the fistula. In one of my cases an opening still remains through which one's little finger may be passed, although I have made five or six attempts to close the opening. The fistulas in all of the other cases were closed in either one or two attempts.

TRANSILLUMINATION

Transillumination was done in all but 1 case. It was probably done in this case, but the record does not show it. Of the 192 cases, 189 showed positive observations. In 3 cases the results were negative.

My feelings regarding this diagnostic aid is that it is as valuable as the roentgen ray. Certainly it is suggestive enough to warrant further investigations which will rule out the presence of disease. No additional expense is added by the use of transillumination, and it should be done as a routine for every patient complaining of nasal symptoms.

Shambaugh stated, "In the case of the maxillary sinus very little is added by the x-ray that is not shown by transillumination, and irrigation of the sinus, so simple to carry out, gives more information than either."

The methods employed included both that of Briggs and the older method of Heryng. In my opinion, both give equal information.

Lockard and Argall expressed the belief that transillumination gives no definite information regarding the antrums.

The simple and inexpensive method of transillumination for diagnosis must be carefully done. I have been disappointed a number of times by positive reports from the roentgen examination when my observations with transillumination were negative. Repetition of the test with more careful observation has changed the results.

DIAGNOSTIC PUNCTURE AND LAVAGE

Two hundred and three diagnostic punctures were made in this series. There were 7 of this number in which I could state from the gross appearance of the returned fluid that the sinus was normal, even though there were positive observations with transillumination and the roentgen ray. In 1 case puncture, transillumination and the roentgen ray gave negative results, but observation at operation indicated chronic maxillary disease, subsequent events justifying the operation.

I have become addicted to the use of this puncture as a simple diagnostic procedure. Recent articles have indicated that in many cases puncture is followed by serious complications and even death. These

articles have attracted widespread attention. Skillern said, "The danger has been exaggerated beyond all degree of its relative importance." He never saw an instance in which needle puncture, "whether properly or improperly done, was even followed by an alarming symptom." As I recognize that this procedure should be done properly, I have never injected air into the cavity until I was satisfied that the needle was free in the sinus. To date I have not had one untoward symptom. Anesthesia is produced by introducing a thin wire applicator beneath the inferior turbinate. (V. Mueller and Company have prepared a thin wire applicator for this purpose.) It may be used with advantage also for sphenopalatine application. It is placed high up in the inferior meatus, two or three drops of 5 per cent solution of cocaine being used. This is permitted to remain for fifteen minutes with the patient in the reclining position, at which time the puncture may be made painlessly and easily, if care is taken to keep the needle high up so as to pass through the maxillary process of the inferior turbinate. This triangular attachment is very thin and is located high up in the meatus about midway back. A special spinal puncture needle, 16 gage, prepared for me by B. D. and Company, is used. This needle should be sharp, and on entering the antrum air should be withdrawn with a syringe before anything is injected into the cavity.

Lockard and Argall did not rely on the ordinary method of diagnostic puncture, but, instead, they used a large trephine opening. Their claim is that often secretions cannot be discovered in any other way. This must be the case but seldom, I think.

For direct exploration of the sinus, Morse recently designed a sinuscope which is an improvement over the similar instruments of Spielberg and Maltz in that it allows of operative manipulations.

Lemere stated that both the roentgen ray and transillumination may show negative results in an infected antrum in which infection was not formerly suspected. Recently I had a case in which neither the roentgen ray or transillumination showed the antrums to be infected, but in which cytologic examination was prepared for because of strong suspicion that the antrums were infected. On withdrawal of the syringe, thick, tenacious pus was obtained. In this case the roentgenogram was not absolutely negative, but the report was definitely against involvement. It is only fair to state that on the injection of an opaque medium the roentgenogram showed a definite thickening of the mucous lining.

It is true that antritis may be present and yet not present macroscopic evidence of pus in the fluid returned. However, while I have had such experience, there are not a great many cases in which flocculi cannot be discovered if the washings are placed in a clear test tube and held to the light for inspection.

THE ROENTGEN RAY

Roentgen examination was omitted in sixty-nine cases. Of the remaining number, the roentgenogram was negative in six; transillumination and diagnostic puncture gave positive results in these cases. My feeling regarding the diagnostic value of this method has been stated under transillumination. A rather interesting observation was made in several cases of bilateral involvement. Transillumination gave negative results on one side and positive on the other, whereas the report from the roentgenologist was precisely the opposite. Whether or not this could have been due to transposition in the reading of the film or in the record of the observations with transillumination, I am unable to state. However, a careful recheck did not change the record.

During the past year, I have had a great deal of experience with the cytologic test of antral contents as described by Sewall. Some interesting observations have been made, and I have been able to confirm Sewall's results. Numerous case histories could be cited in which the cytologic report indicated chronic disease, confirmed by transillumination and the roentgen ray, at the operating table and in the laboratory. Since using this test, I have almost come to the conclusion that it is the most reliable test that can be used for maxillary disease. The technic of this test is fully described in Sewall's article, and I strongly recommend it.

The diagnosis of chronic maxillary sinusitis is usually made from a consideration of the history, symptoms, endonasal observations, results of transillumination and irrigation. To secure further information, the roentgen rays must be used, with or without the use of opaque mediums, cytologic examination and direct exploration. Mithoefer found the tuning fork test of Glas of definite value. A vibrating C2 fork is placed in the midline of the forehead. "If marked changes are present in the antrum, the vibration will be felt more on the affected side."

Recently I had a case in which the roentgenogram was negative; cytologic examination and transillumination gave positive results, and observations at operation showed the entire antrum filled with hyperplastic material, thickened mucous membrane and much pus. This antrum was divided into three distinct partitions by septums.

Roentgen examination is of value not only in diagnosis, but in prognosis as well. By the changes in the shadows one can tell whether or not resolution is taking place. Roentgen examination is a most important diagnostic aid. Nothing that has been, or may be, said in this article is to be construed as a reflection on its merits.

Iodized poppy seed oil 40 per cent reveals the topography of the antrum, the thickness of the mucous membrane and the displacement

of the tissue, and, by the duration of the retention of oil, measures the functional capacity of the ciliated epithelium in eliminating oil from the antrum. Ersner stated that normally the oil should be thrown off within from twenty-four to forty-eight hours. In the chronic suppurative antrum, the oil may remain for ten or twelve days, because of the destruction of ciliated epithelium. Anderson used fluoroscopy as well as roentgenograms in conjunction with iodized oil. In the normal film the bony outline is visible, and the margin of the oil should parallel this at a distance of 1 mm.

Van Osdol found the use of iodized oil of "marked value in distinguishing superficial alterations of the mucosa which will recover by ventilation and drainage, from fungoid degenerations with or without osteitis which require radical measures for cure." He found that the sinus is better filled by injection than by the displacement method of Proetz. To fill the antrum from 4 to 6 cc. of a mixture of 1 part of iodized oil and 1 part of liquid petrolatum is sufficient.

I have used iodized oil for making injections in many of my cases, and I find it quite satisfactory. It has a disagreeable odor and a nauseating taste and is quite expensive. Brominized sesame oil has recently been put on the market and can be obtained in light and heavy viscosities. It is practically odorless and tasteless and is much cheaper and almost as opaque to the roentgen rays as iodized oil. This is an extremely interesting and valuable method of diagnosing the condition of the lining membrane of the antrum. It may be used immediately after diagnostic puncture has been made. This saves the patient a second puncture, and the film of the sinus without contained opaque material may be made a few days or a week later. One should be careful to remove all pus or liquids from the antrum before injecting the oil. My preference is for the heavy type of brominized sesame oil since the lighter oils are apt to run out before the plate is taken.

TREATMENT

All of the cases in this report finally came to operation. In the hope that more conservative methods would suffice, twenty-six cases were subjected to puncture and lavage, varying from six punctures in a given case to sixty in another. In the latter case the patient was so improved with each puncture, at least for a number of days, that he refused operation until after this enormous number of punctures had been made.

"When the patient has a temperature above normal, even irrigation had best be avoided" (Mithoefer). "In some cases, vaccine therapy has seemed of value" (Davis).

Harkness expressed the belief that suction is not without danger in that, if the aspirating tip is withdrawn too suddenly, pus may be aspirated by previously healthy sinuses. He preferred siphonage to simple lavage.

Myerson expressed the opinion that irrigation through the natural opening can be effected in 50 per cent of cases with Yankauer's or Haskin's cannula. When neither of these can be passed, he tries the Pierce cannula. King recently devised an instrument for this purpose. Yankauer also designed a miniature cannula for lavage of the maxillary sinus of infants through the natural orifice.

The Krause operation was performed in all but twenty-one cases; of these the Caldwell-Luc operation was done in nineteen and the Canfield-Ballenger operation in two. It was necessary to do the Caldwell-Luc operation in five cases following a primary Krause window resection.

When radical measures have been necessary, I have found the Caldwell-Luc operation quite satisfactory and entirely adequate for inspecting all parts of the antrum. The entire lining may be removed in this operation, and I have not found it necessary to do the Denker operation. It would seem that the Canfield-Ballenger operation should be ideal, both as a conservative and as a radical measure; however, in the few cases that I have performed this operation, it has been extremely difficult to keep the opening patent, and I have not found it as satisfactory for inspection of the interior of the antrum and for removal of the contents as others have reported. Occasionally there is an annoying anesthesia of the lip, cheek and teeth following a Caldwell-Luc operation. In no instance has this remained permanent, although it has persisted for several months in a few cases.

In his treatment for chronic maxillary sinusitis, Skillern started with irrigation. If the character of the secretion improves and becomes less, irrigation is continued until recovery. "If, however, the improvement is only partial, I employ the next conservative method—the Krause operation."

Hempstead was enthusiastic concerning intranasal surgical treatment for chronic maxillary disease. In the dental cases he reported that the pus was foul, polyps were not formed, and healing was usually rapid after the institution of intranasal drainage. In the cases of nasal origin the healing process was much slower.

Harter viewed both the intranasal operation and the Caldwell-Luc operation with disfavor. He declared that the former is followed by too many recurrences. In the latter operation, the naso-antral window tends to close, the naso-antral wall thickens, irregular suppurative tracts develop in the newly formed bone and disease cannot be properly eradi-

cated in the antranasal angle. He performs the Denker operation in all cases, using local anesthesia. The lining membrane is left in situ if it is smooth and without polyps, but if polyps are present the lining membrane is entirely renewed.

Sewall and Emerson expressed the belief that the Caldwell-Luc operation is entirely adequate. The opening should be kept high on account of the teeth.

Bricca showed that the teeth are rarely permanently damaged.

Hempstead said that anesthesia of the cheek follows radical procedures, and he argued for conservative measures and mentioned the danger of infra-orbital neuralgia. I have not had this unpleasant experience.

In the management of disease of the antrum in childhood, drainage by tube is favored by Alden and Shea. The obturator carrying the tube is pushed into the antrum, where it is permitted to remain, being held in place by a flange on the tube. Mandelbaum used a miniature, and Eynard, a self-retaining catheter. Irrigations are carried out daily through these tubes until the sinus is free from secretion. The initial improvement is gratifying, although Shea held that the attainment of permanent relief is difficult.

Brown, however, expressed the belief that in 98 per cent of cases the patients are cured by this treatment. Drainage by tube has likewise been advocated for adults.

Mercer did not use rubber tubes, but inserted a small, curved, silver tube through the trocar opening and kept the tube in situ for from three to four months.

Olsho emphasized the value of posture in the treatment for disease of the sinus, but Baum agreed with Phillips that probably the most important factor in drainage of the sinuses is ciliary action. He held that the reason the antrum is the most frequently infected sinus is because of the size of its ostium, which makes it accessible to active infection in the nose. The teeth are an additional factor, and are admittedly responsible for at least 15 per cent of the cases. Normally cilia are found on every square millimeter of surface of mucous membrane of the nose and sinuses. The ciliary movement produces a current toward the ostia from within the sinuses, and toward the choanae from within the nose (Yates). Yates expressed the opinion that surgical intervention should be conservative, giving every possible chance for ciliary activity to recover.

POSTOPERATIVE TREATMENT

Subsequent treatment was usually dry; that is, irrigation was avoided, except in the cases in which the discharge was so profuse or so thick

and tenacious that it was necessary to assist gravity. By dry treatment is meant shrinking of the nasal membrane, wiping out of the interior of the sinus with a dry cotton swab or removal of the secretions with a small suction tube. Exuberant granulations were touched with varying strengths of silver nitrate. Care was taken to see that the opening was entirely free into the antrum at each treatment. Chemicals and chemical solutions were not used in any case. Physiologic solution of sodium chloride was the only solution used when irrigations were employed. Irrigation was used exclusively in five cases. A combination of dry with occasional irrigations was used in twenty-seven cases.

Hempstead expressed the belief that irrigation causes a water-logged condition of the mucosa that delays healing, and he did not use it in any case. On the other hand, Skillern uses daily saline irrigations as a routine. If discharge continues, he uses alcohol to irrigate. If no favorable result ensues, a radical operation is essential.

In two cases I had the misfortune accidentally to leave a small gauze sponge in the antrum in closing up the wound after a Caldwell-Luc operation. In these cases the patients did not recover until the sponges were discovered and removed. A patient with a somewhat similar complication came to me following a Krause operation done elsewhere; I discovered the tip of a glass syringe in each antrum, the foreign body acting as the irritant. The accidents that I had certainly should have been avoided, but in the cavity that is bleeding freely and in which one is using gauze sponges to dry it, to forget a sponge is not as impossible as one might surmise.

LENGTH OF CONVALESCENCE

The average number of days noted in the history before the patient was discharged as cured was thirty-seven days. This summary of convalescence is made of 211 cases because 47 of the total had bilateral involvement. The shortest period of convalescence was five days. The longest was two years, until the antrum was finally dry.

ASSOCIATED CONDITIONS IN THE NOSE AND THROAT

There was an apparent ethmoiditis in twenty-five cases. I have now come to regard most of these as "pseudo-ethmoiditis." Chronic tonsillitis with chronic lateral pharyngitis was noted in twenty-two cases. There were two cases of atrophic rhinitis. Severe complications before operation were encountered in but one case, that of orbital cellulitis previously noted. Following operation acute mastoiditis requiring operation developed in one case. In six cases acute otitis media developed, which required incision of the membrane of the drum. Acute tonsillitis

developed in ten cases, in five of which the condition became peritonsillitis. Infection of the lacrimal sac developed in one case; it subsided without operation.

Following the Caldwell-Luc operation, secondary hemorrhage was encountered in two cases. This was not alarming but caused considerable worry for twenty-four hours. It was probably due to exuberant granulations.

END-RESULTS

Complete recovery ensued in all but nine cases. Of the nine, one patient recovered completely, further operative procedures being done elsewhere. The remaining eight disappeared from observation, but were not cured when last seen.

End-Result of Focal Disease.—Two patients with tachycardia and two with persistent rise in temperature in the afternoon recovered completely. The two patients with chronic bronchitis were much improved. The patient with bronchiectasis was improved but not cured. All of the patients presenting vague symptoms of malnutrition, malaise and poor general health gained in weight and felt better in every way. One patient with erythema, one with herpes ophthalmicus and one with persistent urticaria recovered; one case of choroidoretinitis was arrested; two patients with acute nephritis recovered completely. The five patients with asthma were unimproved. Ten patients with rheumatism were completely cured and six were improved and one with corneal ulcer recovered promptly. It is interesting at this point to give the history in a case of rheumatism.

J. K. S., a man, aged 25, who consulted me on Dec. 5, 1927, was referred by Dr. A. G. in an effort to locate a focus of infection. For the past two years he had been suffering from a persistent cervical neuralgia, which had been diagnosed elsewhere as an arthritis of the cervical vertebrae. Otherwise, he was in perfect health. The tonsils had been removed, and all efforts to locate a focus of infection had been unsuccessful. Examination of the nasal passages revealed nothing particularly abnormal. Transillumination showed both maxillary antrums equally dark. Roentgenograms were not made. Diagnostic puncture of the right and the left antrum returned much pus in the washings. The following morning, with the patient under local anesthesia, a Krause operation was performed on each maxillary antrum. Surprising as it may seem, the patient insisted that two hours after the operation "his rheumatism" was gone, and he was able to move his neck and head in all directions. The following day there was a slight return of the cervical distress, which disappeared the next day, and the patient has never complained since. The gross observation at operation consisted in many small polypoid granulations in each antrum with much mucopurulent discharge. Both antrums were dry in eighteen days, and so far as I could tell the lining membrane seemed normal. This patient has been seen a number of times since, and has never had a return of the subjective symptoms.

Wood considered that the production of secondary infection by "dry absorption of bacteria from the nasal sinus is rare but what most often occurred is the absorption of toxin or allergic products." Anemia, emaciation and general inefficiency may result from this cause.

The same author seemed emphatic in his belief that disease of the nasal sinuses per se is not responsible for focal disease, but rather that it plays a secondary part by direct extension to pharyngeal lymphoid tissue, which in turn becomes the focus for other disease.

Quinn and Meyer, in a study of the relationship of sinusitis to bronchiectasis, noted that the aspiration of iodized oil into the lung from the nasal cavity while one is asleep is possible and does occur with apparent ease. Aspiration is hence the most probable explanatory factor for the frequent concomitance of bronchiectasis, bronchitis and sinusitis.

Raffo, on the other hand, expressed the belief that sinusitis and bronchitis are frequently of simultaneous origin, and therefore no causal property may be attributed to the disease of the sinuses.

Daland considered that systemic disease, associated with chronic infection of the sinuses, is associated with leukopenia, lymphocytosis and diminished polymorphonuclear cells in about 40 per cent of cases, and he felt that chronic disease of the sinuses is a definite factor in the production of systemic disease. He concluded that latent or chronic sinusitis is often an unsuspected focus of infection and often coexists with infected tonsils and teeth.

RELATION TO NASAL POLYPS

I have been impressed by the number of cases of chronic maxillary sinusitis in which there was an apparent associated hyperplastic ethmoiditis. Too often one is apt to make a diagnosis of hyperplastic ethmoiditis because the nose is filled with polyps. I have seen some able rhinologists glance into a nose and make an immediate diagnosis of chronic hyperplastic ethmoiditis, simply because polyps were present in the middle meatus. If this is true, how many patients have been subjected to radical mutilating operations on the ethmoid mass which leave the nose in a condition far from normal? I have seen many of what I now know to have been normal ethmoids subjected to radical surgical intervention in an attempt to eradicate these tumors. Invariably the patients have returned, shortly, with a relapse of the same condition. Having made this grave mistake myself, I have sought further for the origin of the nasal polyps.

Twenty-two cases of an apparent ethmoiditis, or what I choose to call "pseudohyperplastic ethmoiditis," are included in this series. All of the patients recovered without undergoing operative measures that destroyed any of the ethmoid cells. All recovered, without the return

of polyps. Nothing was done other than to drain the maxillary sinus and to scalp the polyps from the middle turbinate and middle meatus. This, to me, presents an argument for conservatism in these types of cases.

Hajek, in his textbook, made the significant statement "that the growth of polyps stops when irritating conditions are abated." While he felt that there are undoubted cases in which the polyps are the result of underlying osteitis, his investigations support the theory that there is usually an underlying disease of the sinuses as the cause.

Woakes was the first to state that underlying bone may become diseased with necrotic changes, and he called them the cause of the formation of polyps. Hajek corrected these errors by showing that polyps arise in the mucous membrane, but that an inflammation can secondarily invade the bone. He substantiated this theory and proved that in most cases changes in the bone do not primarily cause polyps. In a number of instances Uffenorde confirmed all of the observations of Hajek. Zuckerkandl found that polyps develop principally in the respiratory zone of the nasal cavity, and he stated that he had never seen them on the floor of the nose or on its roof. This lends additional emphasis to the theory that polyps always originate in areas over which irritating discharges may pass.

In his conclusions, Grunewald stated that nasal polyps in the majority of all cases are as good as pathognomonic for disease of a sinus, the nasal polyps being produced secondarily by the chronic suppuration.

Hirsch, from whose article the foregoing quotations have been made, was satisfied that "recurring polypi have their origin in the sinuses and most often in the maxillary." One may be pardoned, perhaps, if one attacks the ethmoid to eradicate nasal polyps in that region, if consideration is given to the controversy carried on for years regarding the origin of nasal polyps.

My series of cases confirms Hirsch's observations that nasal polyps originate in the maxillary, sphenoidal, frontal, and ethmoidal sinuses, the frequency being in the order named. The cases here reported are those in which I have considered nasal polyps originating exclusively in the maxillary sinus. There are a number of cases in which I have felt that the polyps originated in the other sinuses, but they are not included. Considerable doubt may be felt regarding the cure of these cases by such conservative and simple operative procedures; nevertheless, I have been astonished at the rapidity with which nasal polyps disappear following intranasal maxillary surgical intervention. Cases have been seen in which the antrum was opened intranasally but in which no polyps could be seen in the antrum. In a few days large polyps would extrude through the naso-antral window. Nothing was done

other than to keep the opening patent. What appeared to be a sure case for more radical surgical intervention would go on to complete recovery without it.

Freedman held that the nasal polyp is only a symptom of an underlying osteomyelitis or at least a periostitis of one of the sinuses. If the maxillary sinus is involved, the operator ought to dissect off as much of the lining membrane as possible. Emerson and Mithoefer agreed with this view. The latter attempted to deliver the polypoid tissue en masse, thus avoiding the need of the curet to a great extent.

Hempstead stated, "It is generally agreed that if the antrum is filled with polyps it must be attacked radically; but one is often astonished at the resolution which takes place after thorough drainage and ventilation have been established by conservative measures."

Hirsch reported one case in which he was able to observe the point of origin of a polyp in the antrum from which he could follow a long thin stem to the maxillary ostium, after which it enlarged into a tremendous polyp extending into the choanal space.

In four patients in whom I was able to follow the pedicle of a large choanal polyp through the maxillary ostium, it was attached to the wall of the sinus. In each of these cases the pedicle was a long, thin, attenuated, fibrous band.

The following case confirms the observations of Hirsch:

H. B., a man, aged 36, consulted me on July 28, 1928, stating that one year previously the right upper first and second molar teeth had been extracted by a dentist. Prior to this time he had never had any trouble with his nose, and had always been in good health. When seen, there was a large fistula leading into the right maxillary antrum at the site of the extracted teeth. Pus was constantly flowing from this opening into the mouth, and large quantities of pus were blown from the nose or drawn in the postnasal space. During all this time the antrum had been irrigated regularly by the dentist with no relief from symptoms. The right side of the nose was entirely obstructed, and he had the sensation of a foreign body in the postnasal space. Examination showed the right side of his nose filled with many large polyps, one of which was about to extrude from the anterior naris. Postnasal examination revealed the postnasal space entirely filled with a large mucous polyp. On August 24, a Caldwell-Luc operation was performed and the antrum was found to be filled with polyps. Extending from the outer wall of the antrum through the ostium into the middle meatus was a thin fibrous band. At this point it gradually enlarged into one of the largest polyps I have ever seen, entirely filling the posterior naris and the postnasal space. When the pedicle was detached in the antrum, the polyp slipped into the patient's mouth from the postnasal space. It was slightly larger than an ordinary hen's egg. The mucous membrane lining the cavity was entirely removed; all of the polyps in the nose were stripped off with biting forceps, and the wound into the mouth was closed. In one week the patient had entirely recovered, with the exception that the fistulous opening had broken down again. Two months later another attempt was made to close the fistula by a plastic operation, the tissue from the roof of the mouth being used. This was unsuccessful as the wound

promptly broke down. A third attempt was made to close the opening without success. At the time of writing this article there was an opening about the size of a large lead pencil leading into the mouth from the antrum. Further attempts to close it will be made later. At the time of writing, about two years following the operation, the patient's nose was entirely free and the lining membrane of the antrum had regenerated.

GROSS OBSERVATIONS AT OPERATION

Two cases proved to be dentigerous cysts, requiring Caldwell-Luc operation. When the antrums were opened in fifty-six cases, only purulent or mucopurulent secretions were found. Thirty-nine cases showed pus with much thickened mucous membrane. There were sixty-three cases which showed pus, the mucous membrane being thickened with polyps. No cases of osteomyelitis were encountered. In twenty-two cases the middle meatus was filled with polyps, and in ten of these, the polyps extended into the choanae.

BACTERIOLOGY AND PATHOLOGY

Not many of the cases were followed through to complete bacteriologic and pathologic laboratory reports. This is not hard to understand when one considers that in most instances after the operation has been finished laboratory proceedings add nothing except in a scientific way, and in private practice they add materially to the expense for the patient.

In twenty-six cases cultures were made from the cavity with the following results: Staphylococcus was the predominating organism in twelve cases, pneumococcus and staphylococcus in five, *Micrococcus catarrhalis* in one, streptococcus in one and pneumococcus-pure culture in five.

Sewall noted that the pathologic material accumulated in an antrum may be completely soluble in water and hence not recognizable by irrigation. He injects sterile saline, and withdraws 5 cc. The normal antrum shows no cellular content; low grade infection is productive of mononuclear leukocytes, while the more active processes furnish either polymorphonuclears alone or mixed with mononuclears. Indeed, a simple swab made from the nose and nasopharynx showing leukocytes and lymphocytes is almost diagnostic of infection of the sinus.

Since the recent report of Sewall of San Francisco, I have been using his technic for the cytologic examination of the antral contents. This was used in sixteen of my cases. My observations confirm those of Sewall in that in the more chronic cases mononuclear cells predominate. In chronic cases subject to recurring acute attacks, polymorphonuclear cells are in the majority.

Turner showed that the accessory sinuses are normally sterile. Pyogenic cocci are more responsible than bacilli for suppuration of the

sinuses. *Streptococcus communis* is found alone or in association with *Staphylococcus aureus, Micrococcus catarrhalis* and *Pneumococcus. Micrococcus crassus* was found in nearly 50 per cent of 200 cases studied by Hays. Macpherson found *Staphylococcus aureus* in 14 of 17 cases of acute maxillary sinusitis. Other organisms occasionally found are those of the *Bacillus coli* group, *B. proteus, B. diphtheriae, B. influenzae, B. gangrenae-pulpae, B. necrodentalis, B. perfringens* and *B. ramosus.*

In the two cases of dentigerous cysts the laboratory examinations showed cholesterol crystals within the cavity of the cyst.

In twelve cases in which pus and thickened mucous membrane with polyps were found, sections were sent to the laboratory and the following report was returned: round cell infiltration, columnar epithelium, hyperplasia of the glands, many goblet cells, no cilia, rarefying osteitis and chronic inflammation.

Mullin and Ball noted four types of histologic change in chronic infection of the antrum, namely, edema, fibrosis, leukocytic reaction and glandular hyperplasia or atrophy. Mononuclear leukocytes and plasma cells are encountered most frequently. Eosinophils are practically always present in cases of asthma, and are generally abundant.

When polyps were encountered in one case, the laboratory report was as follows: "There were mucous polyps, epithelial covering of many mucous glands and blood vessels, round cell infiltration and cellular hyperplasia."

Kistner felt "that there are more chronic sinus infections without pus than with it." Indeed, he expressed the belief that it is extremely difficult to tell from examination of the specimen which is present, as the histologic changes have a great similarity and there is no difference in the gross appearance of tissues removed from chronic purulent and chronic nonpurulent cases. This explains why one should not depend on pus as an indication for treatment, for there is great danger of overlooking the milder cases. Here, again, the cytologic test will reveal disease.

OPERATIVE PROCEDURES AND TECHNIC

For a number of years it was my habit to do the Krause operation with cocaine as the anesthetic. During the past few years, however, procaine hydrochloride has been used exclusively; indeed, it is now my custom never to use cocaine in any intranasal operation. I find that all operative procedures in the nose can be carried out quite well with procaine hydrochloride as the anesthetic. While I have never had a serious accident when using cocaine, I have a wholesome respect for its dangerous possibilities. Since discontinuing its use I do not have the depressed, clammy, sweating patient with dilated pupils and occa-

sional collapse. If cocaine is used, the inferior turbinate is covered with a thin layer of cotton saturated with 5 per cent solution of cocaine. A small pledget of cotton saturated with 10 per cent solution of cocaine is also introduced beneath the inferior turbinate and applied against the naso-antral wall. These are permitted to remain for fifteen minutes, when they are removed and the antral wall is rubbed with a small quantity of cocaine-epinephrine mud. Following this, operative procedures may be carried on quite painlessly.

It is sufficient to inject a small quantity of 1 per cent solution of procaine hydrochloride along the superior attachment of the inferior turbinate; then, with a long, fine needle passed beneath the inferior turbinate, one infiltrates the mucoperiosteum of the naso-antral wall with the same solution. It is always well to wait about fifteen or twenty minutes before commencing the operation.

It was formerly my custom to sever the anterior one third of the inferior turbinate with a strong pair of scissors along its superior attachment. It was then fractured upward into the nose, where it was held in place by a large pledget of cotton. This exposes the naso-antral wall sufficiently to resect a large window. I use the Myles chisel to enter the antrum, although I have used the Welleminski punch. After the initial opening has been made, Ostrom's backward cutting forceps are used to extend the opening forward and Weil's forceps to bite out sufficient naso-antral wall posteriorly, above and below. After the window is made, the turbinate is brought down from above and attached by its anterior end with a single silk suture. It is unnecessary to resect the turbinate or to remove any portion of it. When Strucyken's strong nasal speculum is used, the blades are passed beneath the inferior turbinate, where they are forcibly opened. This fractures the turbinal attachment upward; sufficient room is gained thereby to attack the naso-antral wall. Packing is not used.

In the Caldwell-Luc operation no cocaine anesthesia is used. The intranasal anesthesia is now used just as in doing the Krause operation. The entire anterior wall of the superior maxillary bone is infiltrated with procaine hydrochloride, the needle being passed through the labiogingival junction. Finally, injection is made into the sphenopalatine ganglion and then into the superior maxillary division of the fifth nerve. In fifteen or twenty minutes anesthesia is complete, and the operation may be performed without pain. If it is intended to remove any of the antral contents, it is necessary to wipe out the inside of the cavity with small pledgets of cotton saturated in 5 per cent cocaine solution. Polyps and thickened mucous membrane may be removed, if desired, with Weil's forceps. The cavity of the antrum is packed with gauze strips passed through the window beneath the inferior turbinate into the nose.

The wound into the mouth is closed with silk sutures. Packing is removed on the third or fourth day and is not reintroduced. Wiethe, of Vienna, does not bring the packing out through the nose, claiming that it disturbs the mucosal flap. He brings it through the buccal wound, and a small portion of it is removed and cut off each day after the third day until all of it has been removed.

Whether the conservative operation or the radical operation is done, it is always well to remove a small portion from the lower edge of the inferior turbinate about midway back in a V shape. This prevents a frequent complication in which the turbinate almost totally obstructs drainage. In these operations it is well to place the patient in a supine position. With a small tip all secretions and blood can easily be removed with a suction apparatus. J. C. Beck places his patients in a supine position, and prior to operation gives them barbituric preparations in large amounts. This quiets the nervous system, and, when cocaine is used, prevents poisoning. I have not used this method, but find that injections of morphine-hyoscin as a preliminary will produce sufficient analgesia, which, with the procaine hydrochloride, robs the operation of any unpleasant features.

The following case is one in which the Krause operation was inadequate:

Mrs. J. T., aged 29, consulted me in March, 1925, stating that for one year she had had more or less persistent discharge from the nose, with pain over the right side of the face and cheek. Examination of the nose showed a perfectly straight septum with hypertrophy of the middle and inferior turbinates on the right side; purulent discharge streamed from the right meatus. The teeth were normal to roentgen examination. Transillumination gave positive results on that side; a roentgenogram was not made. Puncture and lavage showed a return of a large amount of purulent material. A Krause operation was performed beneath the inferior turbinate, following which the antrum was treated by the usual dry method, with occasional irrigations. One year later, while the patient was free from pain there was still a persistent purulent discharge from that side of the nose and antrum. A Caldwell-Luc operation was performed with the patient under local anesthesia. Many polyps were removed from the interior of the antrum, and the mucous membrane was thoroughly removed. The patient promptly recovered in about three weeks. There were no further recurrences of symptoms.

The following case is one of typical dental disease.

Mr. V. J., aged 40, consulted me in June, 1919, complaining that six months before the left upper second molar had been extracted, and that the dentist had curetted the socket, telling the patient that there was considerable necrotic bone which had to be removed, and which necessitated an opening in the antrum. In the intervals he had been treated by the dentist with daily irrigations through the socket of the tooth. When seen, the patient complained of pus discharging from the fistulous opening into the mouth, with considerable pus discharging from the nose, anteriorly and posteriorly. A roentgenogram of the upper jaw showed no necrotic bone about the fistulous opening, and because this was definitely an infec-

tion of the left maxillary sinus, no further laboratory examinations were made. Transillumination gave positive results, of course; a Krause operation was performed with the patient under local anesthesia; the edges of the fistula were freshened with a curet and closed with two sutures. The patient made a prompt and uneventful recovery in sixteen days.

In ten cases it was felt necessary to do a submucous resection to correct the septal deformity. Of the total number of dental cases, fistulous opening was present in the alveolar process in twelve. There were no serious complications following operation in any of these, except in one in which acute mastoiditis requiring operation occurred. There was one case of infected lacrimal sac, in which the patient recovered without special treatment. The two patients with sarcoma of the antrum died as a result of metastasis.

REPORT OF CASES

Mr. A. S., aged 30, came to me in January, 1920, complaining that for the past ten years he had suffered from recurrent colds on the slightest provocation, at which time he would have more or less aching pain in the right side of his face with mucopurulent discharge for a number of days. Following the ordinary type of treatment at home, he would recover from the attacks. Recently the attacks had occurred more frequently; the pain was more intense with each infection. His general physical health was otherwise excellent, and there was no other complaint. Examination of the nose showed a perfectly straight septum; the turbinates were of normal size and in good position. There was a small amount of mucopurulent secretion in the right middle meatus. He was seen a number of times during these attacks, always with the same symptoms. Examination of the teeth gave negative results; transillumination showed the right maxillary antrum dark; the roentgen report was that this was a case of chronic disease of the maxillary sinus with much thickened mucoperiosteum. Puncture of the antrum showed a return flow of mucopurulent discharge in the washings. This patient was seen a number of times during each of the attacks, when one or two punctures and irrigations of the antrum relieved the condition. In June, 1928, with the patient under local anesthesia, a large window resection of the naso-antral wall was made beneath the inferior turbinate. There was considerable mucopurulent discharge for a number of days, and after the twenty-fifth day the antrum was entirely dry. No treatment other than that of shrinking the inferior turbinate and wiping out the antral cavity daily was used. Since the operation the patient has been completely relieved of all previous complaints, and there has been no recurrence of his trouble.

The following case is one of maxillary sinusitis with apparent hyperplasia of the ethmoid.

Mrs. M. K., aged 50, came to me in April, 1925, complaining that for the past year she had not been able to breathe through the nose. Examination showed a perfectly straight septum with each nasal cavity filled with large mucous polyps; postnasal examination showed the entire choanae filled with large polyps. Roentgenograms of the sinuses showed the right antrum opaque, the left being normal. Transillumination gave positive results on each side. Puncture of each antrum with the injection of physiologic solution of sodium chloride and then withdrawal

with a syringe gave positive evidence of mucopus in each maxillary antrum. The teeth were negative for apical disease. A Krause operation was performed on each side; the antrums were found to be filled with many polyps. As many of these as possibe were removed with the forceps, and the polyps in the area of the ethmoid were removed with a grasping forceps. No attempt was made to open any of the ethmoid cells. The patient made a prompt and uneventful recovery in thirty-five days without any treatment other than that of wiping out each day the opening made under the inferior turbinate.

SUMMARY

1. Intranasal surgical intervention is the operation of choice for a primary attack in all chronic infections of the maxillary sinus. Ninety-four and two-tenths per cent of my patients recovered completely following these procedures.

2. The Caldwell-Luc operation has proved satisfactory as a radical operative measure.

3. Transillumination and the roentgen rays are equally effective as diagnostic aids.

4. Except in selected cases, dry treatment is effective in the after-care, and, in my opinion, is the better procedure.

5. Contrary to popular lay opinion, operative treatment for maxillary sinusitis is justified by the results.

6. Focal disease seems to follow this type of infection.

7. In my opinion, nasal polyps are associated with maxillary disease more often than with infection of any other sinus, and careful investigation of the maxillary sinus should be made in every case of apparent hyperplastic ethmoiditis. Conservative surgical intervention usually suffices in these cases.

8. Sewall's method of estimating the cytologic content of the maxillary antrum seems to be a distinct advance in the diagnosis of this disease.

9. Injudicious curettement of the sockets of the teeth opening into the maxillary sinus is to be condemned. Curettement should always be followed by suitable surgical intervention to close the wound.

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PATHWAYS OF INFECTION IN ABSCESS OF THE BRAIN

REPORT OF FIVE CASES *

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The spread of infection from the tympanum and the mastoid cavity to the substance of the brain in the production of abscess of the brain has been of interest to us for a considerable length of time. Excellent contributions have been made to the literature on this subject, but comparatively little histologic work has been done. Although many of the problems incidental to this subject have been clarified, many still remain unsolved, and the explanations offered in the solutions have been based on theoretical speculation. We have had the opportunity to study five cases of otitic abscess of the brain, and to section serially the petrous pyramid in each; in three cases the abscess was located in the temporal lobe and in two cases, in the cerebellum. These five cases were consecutive, and came to postmortem examination within a period of about eighteen months. In two of the cases operation was not performed, and therefore these cases were of particular value in that the pathologic processes remained undisturbed.

As is well known, abscess of the brain is far more prevalent following chronic than following acute suppuration of the middle ear. Various figures have been given by different authors (Neumann,[1] Heine and Beck,[2] Nühsmann,[3] Alexander,[4] Braun and Friesner [5] and others); in from 75 to 94 per cent of the cases, abscesses of the brain followed chronic suppurations of the middle ear. The duration of the suppuration in the temporal bone may be years or even decades. The presence of

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1. Neumann, Heinrich: Der otitische Kleinhirn-Abszess, Vienna, Franz Deuticke, 1907, p. 49.

2. Heine, Bernard, and Beck, Joseph, in Denker and Kahler: Hirn Abszess, Berlin, S. Karger, vol. 8, p. 201.

3. Nühsmann, T.: Erfahrungen über den otitischen Hirnabszess, Arch. f. Ohrenh-, Nasen- u. Kehlkopfh. **106**:83, 1920.

4. Alexander, G.: Otogenic Cerebellar Abscess, in Alexander and Marburg: Handbuch der Neurologie des Ohres, Berlin, 1923, vol. 2, p. 1427.

5. Braun and Friesner: Cerebellar Abscess, New York, Paul B. Hoeber, Inc., 1916, p. 75.

cholesteatomas in the chronic cases is given as an important factor in the formation of abscess; in from 65 to 85 per cent of the cases, a cholesteatoma was present.[6]

It is of interest to note that four of our five cases followed an acute or subacute suppuration of the middle ear; the oldest abscess occurred eleven weeks and the youngest four weeks (in two cases) from the onset. In the fifth case the age of the abscess could not be determined definitely. Particular attention was given to this point in the consideration of anamnesis. (The possibility of incorrect knowledge on the part of the patient or relative was also taken in consideration.) However, in one case, on histologic study, there was evidence of a probable chronic suppuration of the middle ear. The age of the abscess can be determined with relative ease when it follows an acute involvement of the middle ear; it is more difficult, however, in the chronic cases. Usually the time given is that of the onset of the acute exacerbation, although abscesses of the brain may remain in a latent state from one acute exacerbation to another.[1] Frequently the abscess makes itself evident after the suppuration of the middle ear has ceased.

Various pathways of infection from the middle ear and mastoid to the temporal lobe and cerebellum have been described at length by a number of authors. In a general way, it may be stated that infection spreads from the tympanum and antral cavity by direct extension through the substance of the bone, with necrosis, avoiding or involving the labyrinth or the sinus in its course to the middle or posterior fossa; or infection may spread through sutures, dehiscences and canals for nerves, or by way of the lymphatics and the blood stream, or by a combination of any of these routes. Whereas the labyrinth is involved in about 50 per cent of all of the chronic cases, according to Körner [7] it is seldom involved in the acute cases. In not one of the five cases in our series was there evidence, clinically or histologically, of labyrinthitis. Regarding the first pathway of infection, namely, that by direct extension through necrosis of the bone, Neumann [1] pointed out that infection has a particular affinity for certain groups of cells. In the order of the frequency of involvement, they are as follows: (1) the mastoid process, (2) the sigmoid fossa, (3) the tegmen tympani and the tegmen antri, (4) the pars petrosa, including the labyrinth, and (5) the posterior wall of the external semicircular canal and the posterior wall of the

6. Heine and Beck (footnote 2). Hegener, J.: Statistik der Ohreiterungen und Hirncomplikation beobachtet in der Heidelberger Universitäts Ohrenklinik, 1897-1906, Ztschr. f. Ohrenh. **56**:3, 1908. Michaelsen, N.: Zur Klinik der otitischen Hirnabszess, Ztschr. f. Ohrenh. **67**:262, 1913.

7. Körner, Otto: Die otitischen Erkrankungen des Hirns der Hirnhaute und der Blutleiter, Munich, J. F. Bergmann, 1908, p. 51.

carotid canal. It is maintained that in chronic cases the spread of infection by direct extension through bone is the rule and the other routes are the exceptions. Even in the acute cases, this route of infection is more prevalent than are the routes through the preformed pathways, i. e., dehiscences, the blood stream and the lymphatics. Goerke and others (quoted by Ruedi [8]) expressed the opinion that dehiscences play little rôle in the spread of infection, since many cases of chronic suppuration of the middle ear in which dehiscences were present did not progress to intracranial complications.

Usually the avenue of infection in the production of an abscess of the temporal lobe is via the tegmen tympani and the tegmen antri (Nühsmann,[3] Lewandowsky [9] and others). Nühsmann reported eighteen abscesses of the temporal lobe, in which the suppurative process extended to the middle fossa through the tegmen antri in fifteen cases; in three cases the route could not be determined. He maintained that this pathway must be considered the rule and the others the exceptions. Nevertheless, we have observed that in cases of osteitis of the petrous pyramid not infrequently the spread of infection extended from the tympanum and antrum through the perilabyrinthine cells medially toward the apex, with the production of a deep extradural abscess of the middle or posterior fossa. It is easily conceivable how an abscess of the brain may subsequently be formed from the infection at these sites. Whereas the infection might spread medially toward the apex, it might also spread outward toward the zygoma with the formation of an extradural abscess and an abscess of the temporal lobe. In one of our cases that will be described, the weight of evidence favored this route.

Macroscopically, the bone is usually necrotic up to the dura. This observation was noted in thirty-seven of the forty cases of abscess of the brain described by Körner.[7] He therefore established the dictum that the otitic abscess was always in the immediate vicinity of the diseased bone. However, on gross inspection, particularly at the cortex, a layer of bone may appear normal, although an abscess is present within the cranial cavity. Cases of this type have been reported by Blegrad and Rimini (quoted by Ruedi [10]). At the surfaces of the middle and posterior fossa the cortical bone is usually dense and may be sclerotic or even eburnated. At times, however, there is sclerosis

8. Ruedi, L.: Der otogene Subduralabszes, Monatschr. f. Ohrenh. **64**:3 (Jan.) 1930.

9. Lewandowsky: Der Hirnabzcess, in Handbuch der Neurologie, Berlin, Julius Springer, 1910-1914, vol. 3, p. 1909.

10. Blegrad and Rimini, quoted by Ruedi (footnote 8). Haymann, Ludwig: Zur Pathologie und Klinik der otogene Grosshirnabszess, München. med. Wchnschr. **60**:135, 1913.

of the bone at some distance from the cortex, and the cortex is cellular and consequently offers less resistance to infection.

Wittmaak's [11] view regarding the spread of infection should be mentioned in passing; namely, that in certain cases there exists a hyperplastic condition of the mucous membrane lining the tympanum and mastoid cells which communicates directly through blood vessels with the meninges. In this way the lymphatics also probably play a rôle in the spread of infection. Hence infection may enter the cranial cavity with little or no necrosis of the bone, although this method of extension is more common in the acute than in the chronic cases. It closely resembles the pathway in which an abscess of the brain may be formed following disease of the nasal sinus. According to Hajek,[12] the infection sometimes spreads from the mucous membrane that lines the frontal and sphenoidal sinuses through the diploetic veins into the meninges, while the bone remains macroscopically intact.

It is not definitely known why in certain cases of suppuration of the temporal bone no intracranial complication ensues, while in others that show no greater evidences of disease, meningitis, sinus thrombosis or abscess of the brain occurs. Considerable attention was paid to this point in our study. In all instances it is not clear why a particular type of complication, meningitis, sinus thrombosis or abscess of the brain should result. Various factors have been given in the explanation of this question. The type and virulence of the invading organism (any type of organism may produce an intracranial complication, according to Goerke), marginal perforation, cholesteatoma, anatomic variations, the pathway of infection, the presence of labyrinthitis and acute exacerbations are some of the factors responsible for the cause of abscess of the brain. All of these factors, however, may be considered as causes for the development of the other intracranial complications. The solution of this problem must be sought in the investigations not only along the histopathologic lines, but also along the biochemical lines.

It is of interest to note that in cases of abscess of the brain the adjacent dura may vary considerably in its gross appearance. It may appear normal, discolored, covered with granulations or surrounded by a localized collection of pus; it may be gangrenous, or it may have fistulous openings. The extent of the diseased dura may vary from a small extradural abscess to a large intradural or subdural abscess. Therefore, the appearance of the dura is not always a criterion as to the condition of the brain. One should expect to find an extradural

11. Wittmaak, K., in Henke and Lubarsch: Handbuch der speziellen pathologischen Anatomie und Histologie, Berlin, Julius Springer, p. 102.

12. Hajek: Nasal Accessory Sinuses, St. Louis, C. V. Mosby Company, 1926, vol. 2, p. 620.

abscess more frequently in the chronic cases of necrosis of the bone in which sufficient time is given for the dura to react, than in the acute cases. However, as is well known, extradural abscesses are frequently found in the acute cases as well.

Neumann expressed the belief that the virulence of the organism and the pathway of infection play a rôle in the production of abscess of the brain. While the virulent organisms pass through the preformed ways in the shortest time and produce a diffuse meningitis, the less virulent organisms advance more slowly through the bone and therefore cause a reaction in the dura. In this process the dura acts as a barrier to the infection; it is covered with granulations and becomes agglutinated to the overlying bone. It is believed that the inner layers of the dura are more resistant.

Whereas the spread of infection through the temporal bone and through the dura can be studied with a certain degree of accuracy, its course through the subdural space offers the greatest difficulty for histologic study. Although the gross picture may be seen at operation or at postmortem examination, for microscopic study, the brain with its pia-arachnoidal coverings is usually separated from the temporal bone with its dura, and each is sectioned individually.

In an excellent comprehensive contribution on the subject of subdural abscess, Ruedi [8] recently pointed out the relative infrequency in the occurrence of subdural collections of pus. He attributed this infrequency to the anatomic relationship of the meninges, that is, the close proximity of the dura to the arachnoid and their great powers of resistance and reactivity to infection. Infections of the bone and the dura produce an exudate in the subdural space that soon becomes agglutinated to the arachnoid layers, obliterating this space. The arachnoidea, which is relatively bloodless, offers even greater resistance to infection than does the dura. In time, however, a reaction in the subarachnoid space takes place. The arachnoid, which finally succumbs to the invasion, is perforated, and organization takes place between the dura and the pia-arachnoid and between the pia-arachnoid and the brain with the formation of a localized pachymeningitis and a leptomeningitis. With the extension of this inflammatory process into the brain substance, an abscess of the brain is produced. The so-called surface abscess of the brain, in which only the superficial part of the cortex is involved, may also be formed in this manner. It is interesting to add that Streit and Hayman (quoted by Alexander [4]) have produced abscesses of the brain experimentally by merely infecting the outer layer of the dura. Usually, however, the true abscess of the brain is formed in the medullary layer, while the cortical layer is involved secondarily, if at all. The explanation for this train of events is based on the blood supply

to the brain. Fremel [13] administered injections into the internal carotid artery in animals and then sectioned the brain. He found that the cortex is traversed by small pial vessels and the medulla by much larger ones. A relatively bloodless area is present just beneath the cortical layer. It is in this area that the greatest amount of necrosis of the tissues takes place after the infection has spread through the thrombosed vessels. In 1925, Fremel [14] reported a series of twenty-one cases of cerebellar abscess that were studied histologically at the Neumann Clinic. Two cases were of particular interest in that fistulous tracts could be traced from the bone to the brain, in one case through the fossa subarcuata and in the other through the cortex of the petrous pyramid in the posterior fossa in the region of the sinus. Körner found that a fistula connected the primary focus in the bone and the brain in 42 per cent of the cases.

REPORT OF CASES

CASE 1.—*History.*—H. T., a boy, aged 11, was admitted to the otological service of Dr. Friesner on Jan. 31, 1928, with a history of infection of the upper respiratory tract six weeks previously that was followed in two weeks by pain in the left ear and spontaneous rupture of the drum. A discharge had been noted up to three days prior to admission. The patient had experienced a severe frontal headache ten days previous to admission which had increased in severity. Staggering and falling to the right and vomiting had been noted. There had been no previous aural infections.

Examination.—Physical examination showed that when the patient was standing, he would fall to the right on turning his head to the right and closing his eyes. The following symptoms were noted: nystagmus to the right, the left and upward vertically, was more marked to the right; adiadokokinesis on the left, and ataxia of the upper and lower extremities more marked on the left. The fundi showed papilledema. Examination of the left ear disclosed evidence of a resolving condition of the middle ear, with no postauricular signs. The patient could hear a low whisper. The right ear disclosed a healed, dry perforation. A roentgenogram of the mastoid showed sclerosis. Spinal puncture gave fluid under increased pressure; there were 150 cells, all lymphocytes, and no organisms.

Operation.—A suboccipital craniotomy for left cerebellar abscess was performed. Pus under tension was encountered in the left cerebellar lobe 2 cm. from the surface. The situation of the lesion suggested that its deep surface was close to the petrous bone. Pus was aspirated. A wide incision was made, and superficial cerebellar tissue was removed to lay open the cavity of the abscess.

Course.—The condition of the patient went rapidly downward; the temperature rose to 104.6 F., and the pulse rate declined from 80 before operation to 68 afterward. There was herniation of the tissue of the brain. Spinal tap revealed gram-positive cocci. The patient died ten days after the operation.

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13. Fremel, F.: Morphologie und Wachstums des Kleinhirn-abszesses, Monatschr. f. Ohrenh. **57**:517, 1923.

14. Fremel, F.: Zur Überleitungsfrage entzündliche Mittelohrenkrankungen auf die hintere Schädelgrube, Monatschr. f. Ohrenh. **59**:409, 1925.

Postmortem Examination.—There were no gross abnormalities of the temporal bone. In the brain an operative wound was seen in the left suboccipital region, through which a purulent discharge exuded. On wider exposure, necrotic brain tissue was seen. A large abscess was present in the left cerebellar lobe. The abscess was surrounded by a wide zone of disorganized tissue. Slight thickening of the meninges over the abscess was observed. The abscess almost completely replaced the left cerebellar hemisphere, which showed central destruction of tissue and which was separated from the fourth ventricle by a narrow zone of necrosis. It is possible that there was some extension of the process into the floor of the fourth ventricle, and the latter was somewhat extorted. Microscopic section showed fairly diffuse purulent infiltration in the cerebellum with areas of recent hemorrhage. The surrounding zone was characterized by fibrovascular proliferation.

Histologic examination of the temporal bone revealed that the drum was intact. There was little evidence of inflammatory reaction in the middle ear or in the antrum. In the region of the posterior semicircular canal the pneumatic cells showed cellular infiltration and thickening of the mucosa. The dura adjacent to this was thickened and infiltrated by lymphocytes. In the region of the subarcuate fossa the vessels were increased in number and markedly engorged.

Comment.—This case is unusual and is of particular interest from the clinical standpoint. The acute onset of aural symptoms of six weeks' duration in a patient with an unimportant past history, the scant otoscopic observations, the resolving condition of the middle ear, the excellent hearing and the absence of labyrinthine signs militated against the diagnosis of cerebellar abscess. However, because of the nystagmus and the left-sided ataxia, a diagnosis of left cerebellar abscess was made; an exploratory operation was performed, and a huge suppurative process of the left cerebellar lobe was found in close proximity to the petrous bone. It is interesting to note that the first symptoms of meningeal irritation appeared about four weeks after the onset of otitis media, and shortly afterward an extensive abscess of the brain was found. The combination of a resolving condition of the middle ear and a concomitant intracranial complication is not infrequent. As a matter of fact, the intracranial complication often takes place after the cessation of discharge from the ear. The patient soon succumbed to this fulminating encephalitic process, and on postmortem examination no gross changes were seen in the petrous pyramid. A large cerebellar abscess that almost completely replaced the left hemisphere and communicated with the fourth ventricle was found. There was no evidence of encapsulation, hence the rapid advancement. Serial section of the temporal bone gave no real clue as to the mode of the spread of infection from the middle ear to the intracranial contents (the tympanum showing little changes). However, the dura on the posterior fossa was definitely inflamed. The meager histologic changes in the temporal bone and the short duration of the disease process are points in favor of the opinion that the spread of infection was by way of the blood stream or lymphatics.

CASE 2.—*History.*—M. T., a man, aged 54, was admitted to the neurologic service of Dr. Strauss on June 2, 1928, with a history of diabetes of mild degree for a number of years. There had been a discharge from the left ear for four weeks. On the night before admission, while the patient was riding in a taxi, he suddenly became disoriented and unable to speak or to recognize people.

Examination.—Physical examination revealed total aphasia; the patient was semistuporous; he showed no meningitic signs, pathologic reflexes or apparent gross sensory losses. A marked hypertension, with a blood pressure of 200 systolic and 80 diastolic was noted. The fundi could not be seen. Within twelve hours the patient became comatose. There were no pathologic reflexes, except inward deviation of the right eye. An acidotic breath was observed. Urinalysis showed acetone and 2.9 per cent of sugar. Breathing of the Cheyne-Stokes type was noted.

In spite of vigorous treatment, the patient died twelve hours after admission. Unfortunately, because of his short stay in the hospital, no otoscopic examination was made. Postmortem examination showed no gross changes of the temporal bone.

Postmortem Examination.—Examination of the brain showed that the dura was under increased tension and when reflected revealed the presence of a heavy greenish-yellow exudate that completely covered the surface of the brain. The left temporal lobe showed distinct softening, and when incised permitted the escape of considerable greenish-yellow pus. The abscess cavity was lined by a fairly definite capsule formation. Microscopic sections showed a typical picture of the wall of an acute abscess of the brain. The meninges presented a picture of an acute, diffuse, purulent meningitis.

Histologic examination of the temporal bone showed the tympanum and antrum filled with purulent exudate and granulation tissue, with organization of the latter. The mucosa was thrown into various folds with formations of granulomas. A perforation was seen in the lower portion of the tympanum, the margins of which were covered by epithelium. This epithelial lining extended into the tympanum, with the formation of a cholesteatoma. In the attic there was a huge perforation that was obliterated by a granuloma extending into the external canal (fig. 1). The greatest amount of inflammation took place in the cells of the roof of the antrum and epitympanum and extended up to the dura (fig. 2). Prussak's space and the epitympanum were bridged by fibrous bands.

Comment.—This case is of considerable interest from the diagnostic standpoint. The patient had been diabetic for years, and had had a discharge from the left ear for four weeks, when, according to the history, he suddenly became semistuporous and aphasic. There were no meningeal signs. Hypertension was noted; the blood pressure was 200 systolic and 80 diastolic, and signs of acidosis were noted. The patient died twelve hours after admission; consequently, a complete study could not be made. The diagnosis of diabetic coma or cerebellar insult due to hypertension was the most plausible in view of the meager meningeal signs. However, in the presence of a history of a pathologic aural condition, although of short duration, and the aphasia, an abscess of the temporal lobe was considered. On postmortem examination the latter diagnosis was verified. There were no gross changes in the

temporal bone. On section, there were evidences of chronic suppuration of the middle ear, necrosis of the bone in the epitympanum with the formation of a cholesteatoma and perforation of the attic with a granuloma protruding through it. Undoubtedly, in this case, in spite of the history, the infection of the middle ear had been of long standing. Owing to the lack of drainage, together with the presence of a cholesteatoma, the infection involved the epitympanic cells, causing necrosis of the bone and invading the overlying dura and intracranial contents.

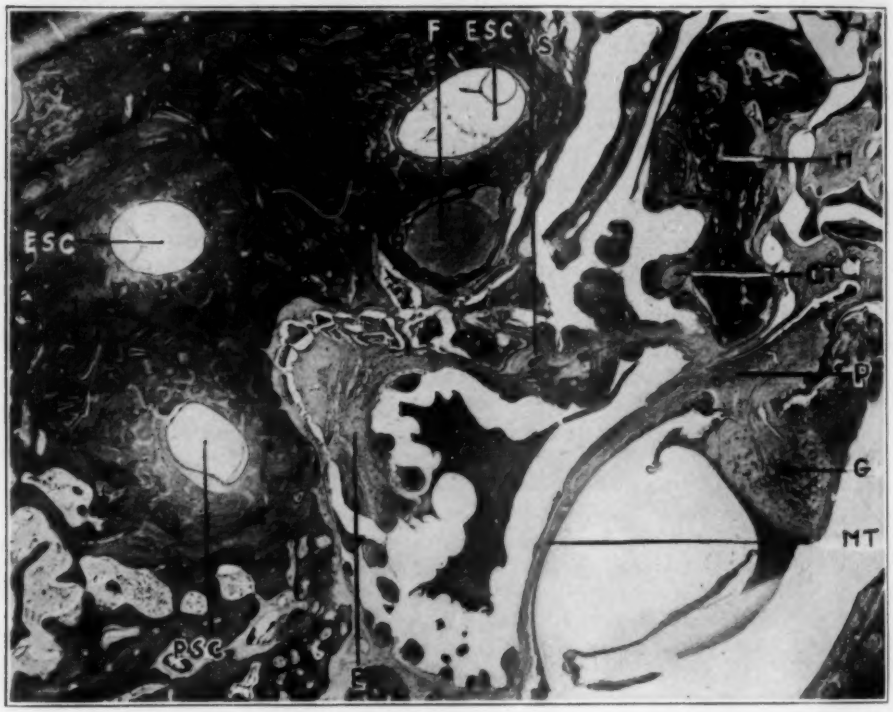

Fig. 1.—Vertical section through the tympanum, showing the severe inflammatory changes in the middle ear. A large perforation in the tympanic membrane through which a large granuloma can be seen extending into the external auditory canal. *E* indicates the purulent exudate in the tympanum, the mucosal lining of which is markedly necrotic; *MT*, the tympanic membrane; *P*, the perforation of the tympanic membrane; *M*, the malleus; *G*, the granuloma; *CT*, the nerve of the chorda tympani; *F*, the facial nerve; *IS*, the inco stapedial joint; *ESC*, the external semicircular canal, and *PSC*, the posterior semicircular canal.

This is the usual route. A comparatively large abscess with a definite capsule was found. This observation is of particular interest since the patient showed no signs until one day before admission. It must be borne in mind that in elderly persons, particularly in persons with

diabetes, considerable necrosis of the bone can take place with few signs or symptoms. That an abscess of the brain may also exist for a considerable time without any symptoms is a well established fact.

CASE 3.—*History.*—B. R., a boy, aged 8, was admitted to the neurologic service of Dr. Strauss on June 23, 1928, with a history of otitis media in the right ear and mastoiditis following scarlet fever eleven weeks previously, necessitating mastoidectomy. The child had been in good health until one week prior to admission, at which time he suddenly complained of severe frontal headache and pain over the right eye; he vomited, and had a temperature of 101 F.

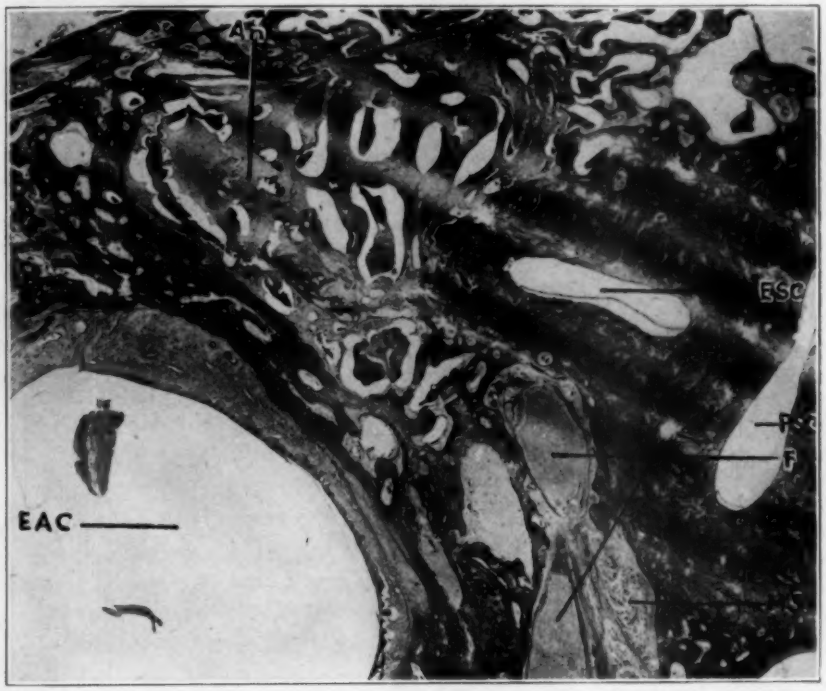

Fig. 2.—Vertical section through the antrum, showing the marked inflammatory changes in the antrum and periantral cells. *An* indicates the antrum; *EAC*, the external auditory canal; *F*, the facial nerve; *MS*, the stapedeus muscle; *ESC*, the external semicircular canal, and *PSC*, the posterior semicircular canal.

Physical Examination.—On admission, the patient showed slight drowsiness, lateral pulsation to the left, depressed deep reflexes, absent abdominal reflexes on the right, and slight nystagmus to the right, with less to the left. Hearing was somewhat impaired. Examination of the fundi showed the left disk blurred, marked dysmetria and ataxia of the right extremity and spontaneous past-pointing to the right. The right ear drum was flat and thickened, with all landmarks visible. The postauricular wound was almost entirely healed, except for a fistula at the lower margin with practically no discharge. The left ear was normal.

A diagnosis of right cerebellar abscess was made.

Operation.—Craniotomy was performed, and drainage for right cerebellar abscess was instituted. At a depth of 4 cm., about 60 cc. of pus under pressure was encountered and evacuated. This was followed by a flow of fluid resembling cerebrospinal fluid. The cerebellum, which at first was tense, soon fell away from the dura after the evacuation of the pus. A culture of pus from the abscess showed *Streptococcus hemolyticus.*

Course.—Following operation, the pupils became unequal. A left facial paralysis and a left Babinski sign were also present. There was an increase in papilledema. The patient then showed marked improvement; the nystagmus cleared up, and the wound was healing. However, on the patient's discharge from the hospital on August 24, about two months after the operation, an ataxic attitude of both right extremities was still present. The patient was readmitted about seven weeks later with a history that he had been well until two weeks previously, when he had begun to vomit, and complained of dizziness, generalized headache and drowsiness. Physical examination showed the head inclined to the left. Papil-

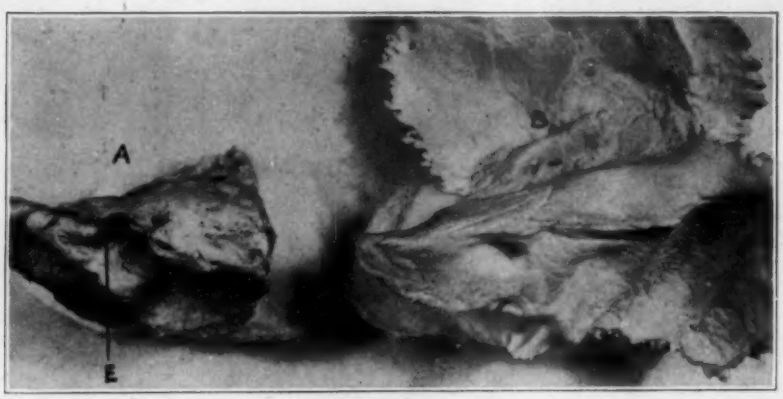

Fig. 3.—The petrous pyramid after removal, showing the eroded area on the posterior superior margin in the region of the internal auditory meatus. *A* indicates the diseased petrous pyramid; *B*, the normal temporal bone for comparison, and *E*, the erosion of the bone.

ledema of from 2 to 4 diopters was noted. The bilateral nystagmus was more marked to the right.

Second Operation.—A second operation was performed; aspiration and drainage of the cerebellar abscess were instituted. Pus was obtained on aspiration, and a drainage tube was inserted. The patient's condition became worse; he was apathetic and stuporous, and meningeal signs were noted. Operation was again performed with aspiration of pus, about 25 cc. being obtained. The child died on the following day.

Postmortem Examination.—On the superior posterior margin of the petrous pyramid of the right temporal bone there was a defect in the cortex of the bone measuring about 2 by 1 cm. (fig. 3). This defect was in close proximity to the internal auditory meatus with which it seemed to communicate. The adjacent bone appeared necrotic, and was friable on probing. The dura over this area was perforated; its margins were thickened and inflamed and separated from the underlying bone.

The brain was voluminous and showed evidence of increased intracranial tension. The meninges showed moderate dulness in places, but there were no frank inflammatory changes, excepting over the posterior lobe of the right cerebellar hemisphere, where the meninges were scarified and adherent to the equally scarified tissue of the cerebellar hemisphere. The latter area of scarification measured 2 cm. in the anteroposterior diameter. Posterior to the abscess the cerebellar cortex was replaced by a narrow zone of scarred material. On microscopic examination, sections showed a diffuse inflammatory process involving the cerebellum and the overlying meninges. The tissues were widely infiltrated with mononuclear leukocytes. There were dense accumulations of smaller cells in the perivascular spaces. There was likewise a marked proliferation of the fibrous connective tissue. Small areas of hemorrhage and degeneration were also seen. The meninges were thickened and infiltrated with inflammatory cells and fibroblasts.

Histologic examination of the temporal bone showed a marked defect in the cortex of the bone, on the posterior surface of the petrous bone in the region of the internal auditory meatus, and the adjacent bone was markedly infiltrated with lymphocytes, polymorphonuclears and red blood cells. There was also sequestration of the bone (figs. 4 and 5). In some areas of the bony lacunae, large collections of giant cells were present. This involved area communicated with the internal auditory meatus, where there was, however, a comparatively small amount of cellular infiltration. The periosteum, that is, the dura lining the internal auditory meatus, was slightly thickened and infiltrated. The labyrinth was intact. The middle ear and mastoid showed slight or no inflammatory changes. However, some of the perilabyrinthine cells in the region of the middle fossa were slightly involved, but not nearly to the extent of the involvement of bone in the region of the internal auditory meatus.

Comment.—This case resembled the first in that the abscess also followed an acute suppuration of the middle ear. The signs indicating the involvement of the meninges and brain appeared ten weeks after the onset of the illness, at which time the condition of the middle ear had practically resolved. The hearing was relatively good, and labyrinthine signs were absent. On admission, the signs pointed to a right cerebellar involvement, and on exploration a huge cerebellar abscess, from which 40 cc. of pus was evacuated, was found. The child showed rapid signs of improvement and was discharged about two months after the operation, although some ataxia was still present. He continued to do well until five weeks later when cerebellar signs reappeared, which necessitated further exploration and drainage. There were no signs of improvement, and the patient succumbed. On postmortem examination a large area of necrosis on the posterior surface of the petrous pyramid was found, at which site the infection evidently entered the intracranial contents. The tympanum showed little pathologic change, and the infectious process could not be traced with any definite certainty from there to this area of necrosis in the petrous pyramid. The labyrinth was spared, as in the first case, and since some of the perilabyrinthine cells showed inflammatory changes, mild though they were, the weight of

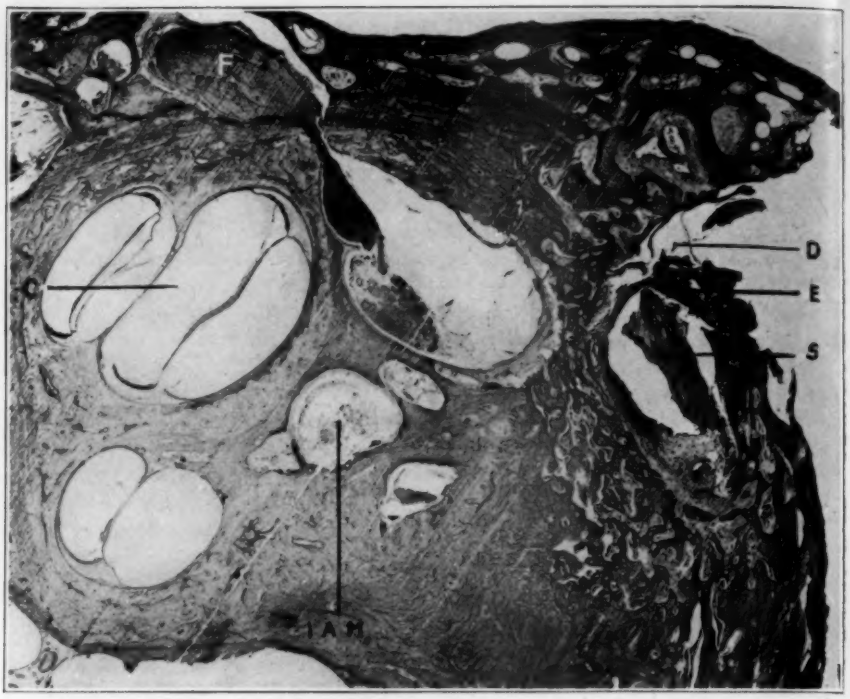

Fig. 4.—Vertical section through the cochlea, showing a large defect on the posterior aspect of the petrous pyramid containing a sequestrum of bone and filled with purulent exudate. The adjacent bone shows necrosis. *D* indicates a defect in the petrous pyramid; *E*, a purulent exudate; *S*, a sequestrum of bone; *C*, the cochlea; *F*, the facial nerve, and *IAM*, the internal auditory meatus.

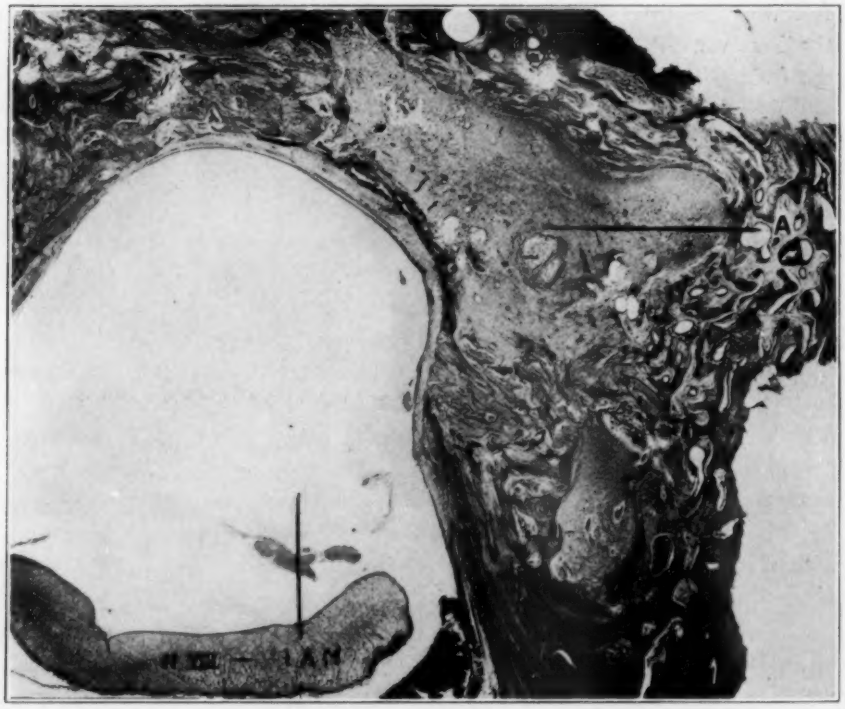

Fig. 5 (case 3).—Anterior section, showing abscess in the petrous pyramid in close proximity to the internal auditory meatus. *A* indicates the abscess in the bone; *IAM*, the internal auditory meatus, and *N VIII*, the auditory nerve.

evidence pointed to this route as the avenue of infection through the petrous pyramid. This is another example that demonstrates the point that the inflammatory process may subside in one area and still advance with increasing severity in another. Again it should be mentioned that although the signs of abscess of the brain were only of one week's duration, a large abscess containing 40 cc. of pus was found; however, a capsule was not present. It is fully understood that neither the presence of a capsule, nor the size of the abscess is always a criterion as to the age of the abscess.

CASE 4.—*History.*—A. G., a boy, aged 6, was admitted to the service of Dr. Schick on Dec. 6, 1928, with a history that he had been in excellent health until one week previously, when he had begun to complain of headache and pain in the left ear. The temperature was 103 F. The following day the patient complained of pain in the right ear. Spontaneous rupture of the left drum occurred on the third day. The fever and headache continued until the time of admission.

Examination.—Physical examination revealed a stiff neck and bilateral Kernig and Brudzinski signs.

Local examination of the right drum showed slight fulness posteriorly, but all landmarks could be seen. The hearing was good. There was an external otitis in the left ear, which made it impossible to see the drum. The hearing was good. A postauricular tenderness was attributed to a possible external otitis. Roentgenograms of the mastoid showed haziness throughout, which was more marked on the left side, but there was no evidence of breaking down. The fundi were normal. A culture of the blood was sterile. Lumbar puncture showed the fluid under normal pressure and a smear revealed the presence of intracellular and extracellular organisms suggestive of meningococcus.

Treatment and Course.—Antimeningococcus serum was administered. Repeated lumbar puncture failed to reveal the presence of organisms on smear or culture. At the end of five days, the child showed definite signs of improvement; the temperature declined to normal, and the condition of the ears was completely resolved. On December 31, the patient was discharged with a diagnosis of meningococcus meningitis (?).

The patient was readmitted on May 28, 1929, with the history that he had been well since discharge, until seventeen days previously, when he suddenly vomited. At that time the temperature was 102 F. Three days later, pain was felt in the left ear. A myringotomy was performed. There was a discharge from the ear for nine days. The patient remained comparatively well except for a slight rise in temperature until twelve hours prior to admission, when he suddenly awoke from sleep, complained of severe frontal headache and vomited.

Physical examination at this time revealed an acutely ill child with stiffness of the neck, a suspicious Kernig sign and a bilateral Babinski sign. Slight nystagmoid jerks of the eyes in both directions were noted.

Examination of the ears showed that both middle ears were normal. A roentgenogram revealed haziness throughout the left mastoid, with no evidence of breaking down. The right mastoid was normal. Lumbar puncture revealed fluid under increased pressure, with 400 cells, 67 per cent of which were polymorphonuclears. A smear showed Gram-positive extracellular cocci. A culture of the spinal fluid was sterile. Antimeningitic serum was administered. The patient

gradually became more stuporous; the fundi showed an increase in papilledema, and the meningeal signs increased. There was evidence of right homonomous hemianopia. A diagnosis of temporosphenoidal abscess was made and operation was advised, but the patient had convulsive seizures and loss of consciousness. He suddenly expired.

Postmortem Examination.—On the inner aspect of the root of the zygoma in the temporal bone there was a circular area about 1 cm. in diameter to which the meninges were closely adherent, and from which they were separated with some difficulty. The dura was perforated in many places over this sharply circumscribed area, giving it a sievelike appearance (fig. 6). The exposed bone appeared necrotic, and contained considerable dark red pigment. The adjacent dura was thickened and inflamed. The remainder of the temporal bone was apparently normal.

The dura of the brain was under increased tension; the brain was voluminous. The vessels on the surface of the brain were injected. The pia-arachnoid was

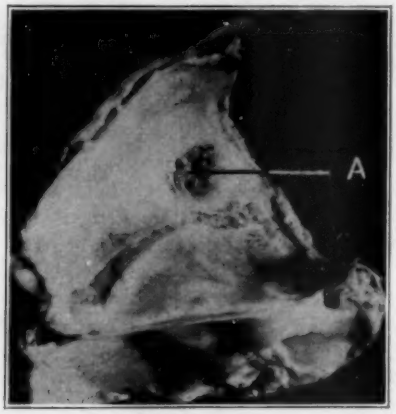

Fig. 6 (case 4).—The temporal bone after its removal, showing the necrotic area (*A*) of the bone on the inner aspect of the root of the zygoma.

faintly milky. The left temporal lobe presented a bulging appearance, and was soft and fluctuating. The leptomeninges at the temporal lobe on that side were adherent to the roof of the zygomatic area of the middle fossa. When this adhesion was broken, a circumscribed, darkened erosion of the dura and bony roof, that measured about 1 cm. in diameter, was seen. Aspiration of the large fluctuating mass in the temporal lobe yielded copious greenish, purulent fluid.

Microscopically, a section through the wall of the abscess showed the typical organization of an abscess of long duration.

Histologic examination of the temporal bone showed that in the cavity of the middle ear the epitympanum and the perilabyrinthine cells were infiltrated by small lymphocytes and by large giant cells that contained many nuclei varying in size and shape (fig. 7). The nuclei were evidently of the histiocytic variety, and appeared to have their origin from the young embryonal connective tissue. The mucosa that lined the tympanum was thickened. This inflammatory process became more and more marked in the cells of the roof of the antrum and in the zygomatic process (figs. 8 and 9). Some of the cells were in direct communica-

tion with the dura through granulations and blood vessels. The inner aspect of the zygoma was necrosed, as evidenced by large lacunae and resorption spaces lined by osteoclasts, and by the formation of sequestrums. There were islands of formation of new bone. The dura lining the middle fossa, particularly in the region of the zygoma, was thickened from five to six times the normal size and showed various stages of inflammation; the outer layers were markedly infiltrated with cellular elements—small lymphocytes, polymorphonuclears and red cells. The vessels were markedly dilated and engorged, and some showed definite thromboses. The lymphatic vessels were likewise dilated. In this region the inner layers of the dura were entirely disorganized and necrotic; cells were sparse, but contained considerable pigment.

Fig. 7 (case 4).—Vertical section through the first turn of the cochlea, showing purulent exudate in the tympanum in the region of the round window. *C* indicates the cochlea; *Pr*, the promontory, and *E*, the exudate in the region of the round window.

Comment.—Here again the case is of tremendous interest, not only because it demonstrates the difficulty of establishing a diagnosis of abscess of the brain but also because of the uniqueness in the spread of infection. Meningeal signs developed in the child one week after an acute process in the middle ear, at which time the condition of the middle ears had practically resolved. Lumbar puncture revealed the presence of intracellular and extracellular gram-positive organisms.

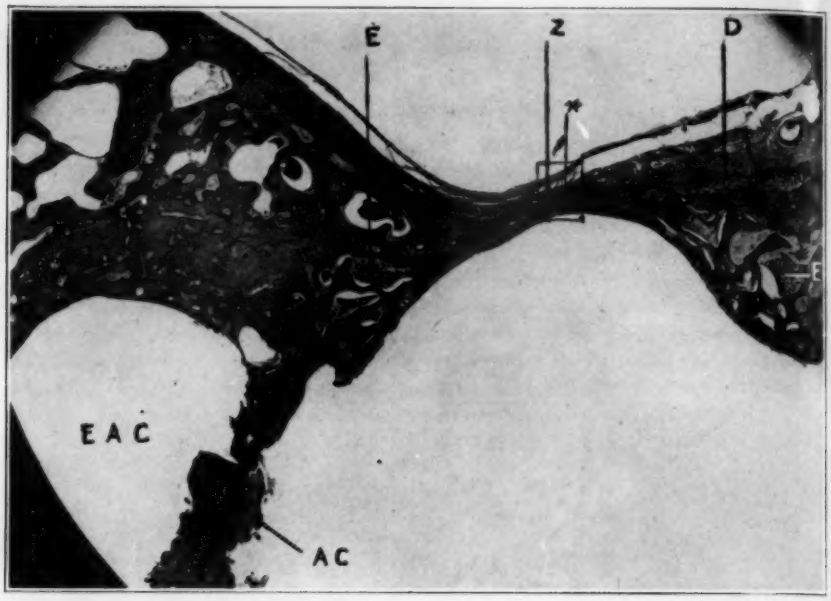

Fig. 8 (case 4).—Vertical section lateral to that in figure 7, through the external auditory canal and zygoma, showing the spread of infection through the cells in the root of the zygoma into the adjacent dura. *EAC* indicates the external auditory canal; *AC*, the anterior wall of the canal; *Z*, the zygoma; *E*, the purulent exudate in the cells of the zygoma, and *D*, the dura, markedly thickened and inflamed.

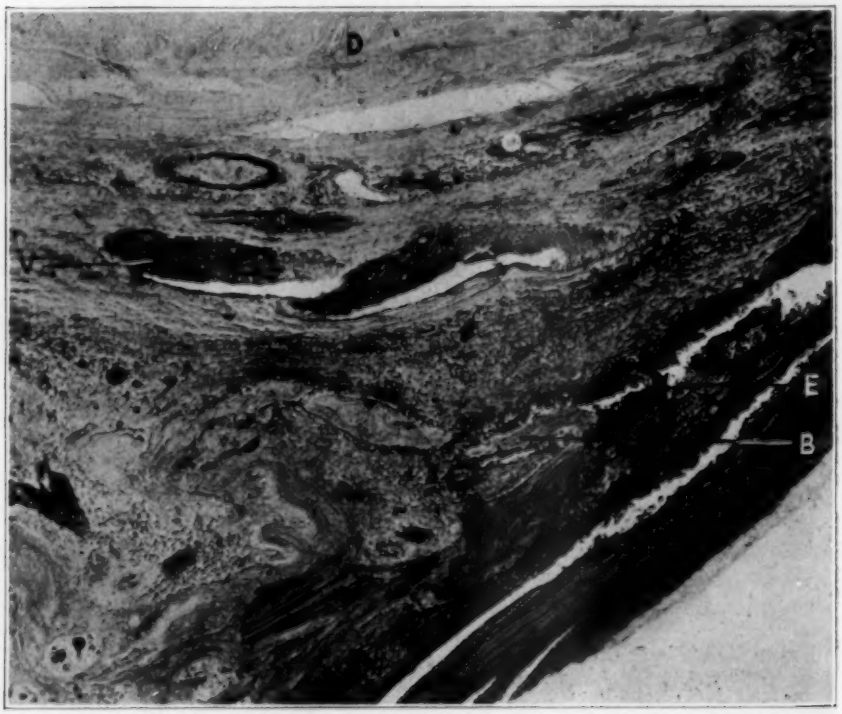

Fig. 9 (case 4).—Higher magnification of the section marked with an asterisk in figure 8, showing the severe inflammatory changes of the root of the zygoma, marked purulent exudate, thromboses of the vessels and necrosis of the bone. *E* indicates the purulent exudate; *B*, the necrosis of the bone; *D*, the dura, and *V*, thromboses in the vein.

The patient was treated with serum for epidemic meningitis, and apparently made a complete recovery. He was discharged from the hospital, only to return about five months later with another attack of pain in the ear, necessitating myringotomy, which is associated with marked generalized meningeal signs. These signs finally showed evidences of localization (namely, bitemporal hemianopia) in the temporal lobe, and when the diagnosis of abscess of the brain was made, the child suddenly died before operative intervention could be carried out. On postmortem examination, a circumscribed area of necrosis was seen on the inner aspect of the root of the zygoma to which the meninges and the substance of the brain were attached. At this site in the temporal lobe a large abscess was encountered. The observations on the spinal fluid, namely, the suggestions of the presence of meningococci, were misleading. There was undoubtedly an early involvement of the dura over the epitympanum and the roof of the antrum one week after the onset of the infection of the middle ear, which was manifested by the meningeal signs and symptoms. These signs and symptoms subsided with the arrest of the infection in this area. The infection, however, continued to spread slowly toward the zygomatic process, which it perforated, involving the dura on its outer aspect and causing an agglutination between the bone and the meninges, and finally between the meninges and the brain with the production of an abscess of the brain. With the acute exacerbation of the infection of the middle ear four and a half months after the first attack, the meningeal signs reappeared and afterward localized in the temporal lobe. As Neumann [1] and others pointed out, an acute exacerbation of suppuration of the middle ear may be an important factor in the manifestation of symptoms of abscess of the brain. This case also demonstrates two important clinical features: (1) the necessity of exenterating completely all pneumatic cells of the mastoid process including cells far forward in the zygoma and at operation to expose diseased dura over a wide area, and (2) the advisability of establishing an early diagnosis. Rejtö [15] expressed the belief that the high mortality in cases of abscess of the brain is due to late diagnosis, and he agreed with Neumann that the more certainly the diagnosis of abscess of the brain can be established by clinical symptoms, the worse the prognosis.

The histologic study of this case was of considerable interest in that at first the infectious process could not be traced definitely from the tympanum and mastoid cavity to the necrotic area at the root of

15. Rejtö, Alexander: Cerebellar Abscess, Monatschr. f. Ohrenh. **63**:670 (June) 1929.

the zygoma. Since there are so few changes in the middle ear and such severe localized changes in the zygoma, the first question that arose was: Is it not possible that the changes in the zygoma are secondary to the abscess of the brain; namely, that the infection spreads from within outward? A perforation of the bony cortex at the zygoma in the production of abscess of the brain is most unusual. To our knowledge only one such case has been reported, and in this case the abscess of the brain was secondary to an external otitis (Hutchinson and Greenwald, quoted by Lewandowsky[9]). Also it is well known that an abscess of the brain may perforate spontaneously, either inward to the ventricles or outward through the dura into the bone. The latter outcome is by far less frequent than the former. The second question was: Did the break in the cortex take place in the roof of the tympanum or of the antrum, and did the infection spread from there along the dura up to the zygoma and localize at that site only to involve the adjacent tissue of the brain, on the one hand, and the adjacent bony cortex, on the other? The following factors favored this view: the early meningeal signs, the marked inflammatory changes in the dura for a considerable area along the middle fossa and the fact that in some cases of intracranial suppuration the infection spreads along the inner layers of the dura, the "Kambium" layer, parallel to the surface of the brain, only to make itself evident at some distance from the site of entry, as was recently pointed out by the writers.[16] The answer to the preceding two questions was revealed by a further study of the slides which showed that the most likely route of infection from the tympanum and the antrum was by direct contiguity along the cells on the roof of the antrum extending forward toward the root of the zygoma where the severest changes took place. The other two possible routes of infection had to be discarded.

CASE 5.—*History.*—N. G., a man, aged 26, was admitted to the otological service of one of us (I. F.) on Aug. 5, 1929, with a history of severe pain and tinnitis in the right ear following swimming four weeks previously. Myringotomy was performed; a purulent discharge was noted until five days before admission. The cessation of the discharge was followed by postauricular pain, which radiated to the right eyeball. There was a reappearance of the discharge on the day of admission. The patient appeared acutely ill; the temperature was 101 F., the pulse rate, 52.

Examination.—Examination of the right ear showed a thick, creamy, purulent discharge from the myringotomy opening. Sagging of the superior posterior wall of the canal and tenderness over the mastoid were observed. Hearing was impaired.

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16. Friesner, I., and Druss, J. G.: Osteitis of Petrous Pyramid of Temporal Bone, Arch. Otol. **12**:342 (Sept.) 1930.

Operation.—A simple mastoidectomy was performed; considerable necrosis of the bone was found. The disease extended up to the dura, which, however, was not grossly involved. Pus was found in the zygoma. The middle fossa was exposed. A culture of pus from the mastoid revealed pneumococcus III.

Course.—Following the operation, blurring of the margins of the disks, mild meningeal signs, headache, severe pain in the right eye, vomiting, unequal pupils and slow pulse were noted. The observations made by the neurologist were suggestive of an early lesion in the right temporosphenoidal lobe. There were signs of an early optic neuritis that gradually increased in severity. Lumbar puncture revealed clear fluid under increased pressure. On August 22, an exploratory operation was performed for a right temporosphenoidal abscess. The mastoid wound was reopened and found to be healing by granulation tissue; the granulation tissue over the dura of the middle fossa extended far anteriorly.

Normal dura was exposed behind. The exposed dura seemed to bulge into the mastoid cavity. It was deemed advisable to make a new craniotomy opening. A trephine opening was made in the temporoparietal region. The dura appeared normal except for the lack of pulsation. The needle was introduced downward and forward at a distance of 4 cm. from the surface; about 1 ounce (28 Gm.) of yellowish-green pus was obtained. The wound was drained. On the following day, the patient became stuporous; rigidity of the neck was observed, and he expired.

Postmortem Examination.—Gross examination of the temporal bone showed that except for a mastoidectomy wound that was healing, and the thickening of the dura over the antrum, there were no changes.

Macroscopic examination revealed that the brain was voluminous under moderately increased pressure. The right hemisphere was larger than the left. The meninges over the left hemisphere showed marked infiltration. There was an area of discoloration directly above the cisterna magna due to the extravasation of blood. On sectioning, there was a large area of softening in the right temporal lobe. In the posterior part of this area there was some indication of the formation of capsules. The area measured 5 cm. in length and 3 cm. in width; it was dark brown and showed many hemorrhagic foci. A tube was found inserted into the temporal lobe with its central end in the outer margins of the softened area.

A diagnosis of a circumscribed suppurative area of the right temporal lobe was made.

Histologic examination of a section through the wall of an abscess of the brain showed a layer of necrotizing tissue infiltrated with polymorphonuclear leukocytes. There was no striking evidence of a capsule.

On histologic examination, the temporal bone showed a purulent secretion in the middle ear and antrum; the antral cavity showed various stages of inflammation, exudation, organization and granulation tissue. The mucosal lining of the tympanum, the antrum and the adjacent pneumatic cells of the petrous pyramid was exceedingly thickened and inflamed (fig. 10). There was evidence of the formation of new bone about the antrum in the process of healing. The dura over the antrum exposed at operation was somewhat thickened and showed mild inflammatory changes; this inflammatory process in the bone extended along the supralabyrinthine cells toward the posterior fossa. At the superior posterior margin of the petrous pyramid behind the vestibule was a large abscess beneath the cortex with considerable necrosis of the bony septums, as was evidenced by the osteoclasts that lined the large resorptive spaces. The inflammatory changes were most

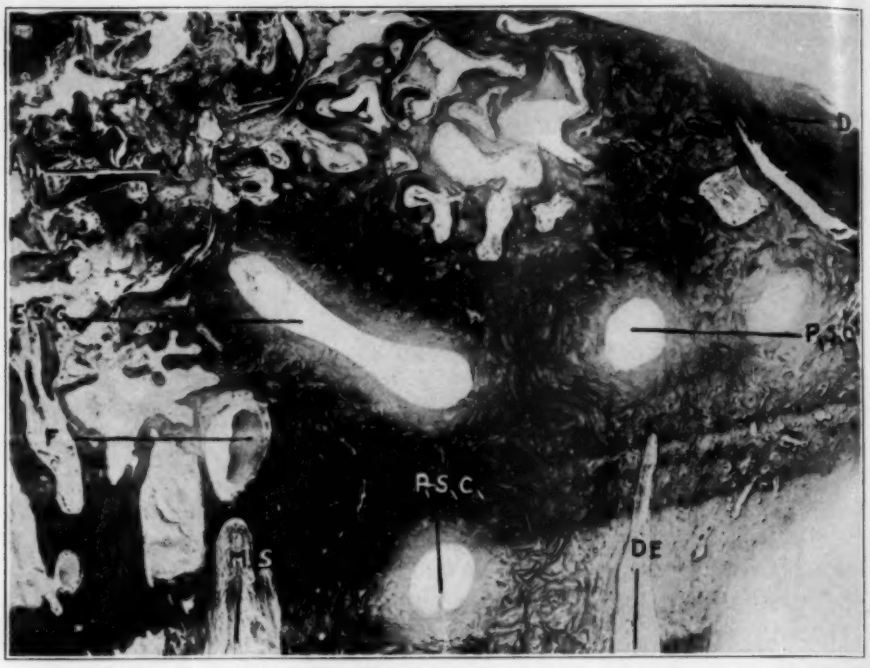

Fig. 10 (case 5).—Vertical section through the antrum, showing marked inflammatory changes in the cells of the petrous pyramid about the antrum. The dura at the superior posterior margin of the petrous pyramid is thickened and inflamed. *An* indicates the inflammatory changes in the antrum and adjacent cells; *ESC*, the external semicircular canal; *PSC*, the posterior semicircular canal; *F*, the facial nerve; *MS*, the stapedius muscle; *DE*, the ductus endolymphaticus, and *D*, the dura.

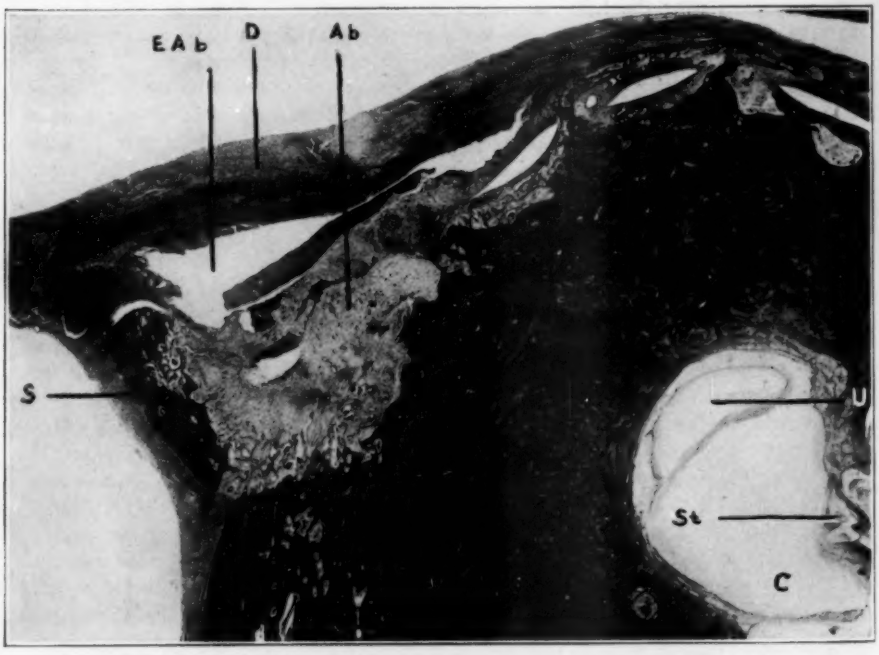

Fig. 11 (case 5).—Vertical section through the vestibule, showing a large abscess in the superior posterior margin of the petrous pyramid with the formation of a sequestrum and the production of an extradural abscess. *Ab* indicates the abscess in the petrous pyramid; *EAb*, the extradural abscess; *D*, the inflamed dura; *S*, the sequestrum; *U*, the utricle; *St*, the stapes, and *C*, the cochlea.

marked at this site. There was an actual perforation of the cortex of the middle fossa with the formation of bony sequestrums. A huge subdural collection of pus with the formation of an abscess was present. The dura was markedly thickened to about seven times the normal size; it was inflamed and infiltrated with lymphocytes. A large intradural abscess was also present. Within the dura the vessels were thrombosed and increased in number and size (fig. 12).

Comment.—The outstanding feature in this case is the production of an abscess of the brain from an acute fulminating infection of the middle ear of pneumococcus III variety. The important rôle that this organism plays in intracranial complications is well known at this time.

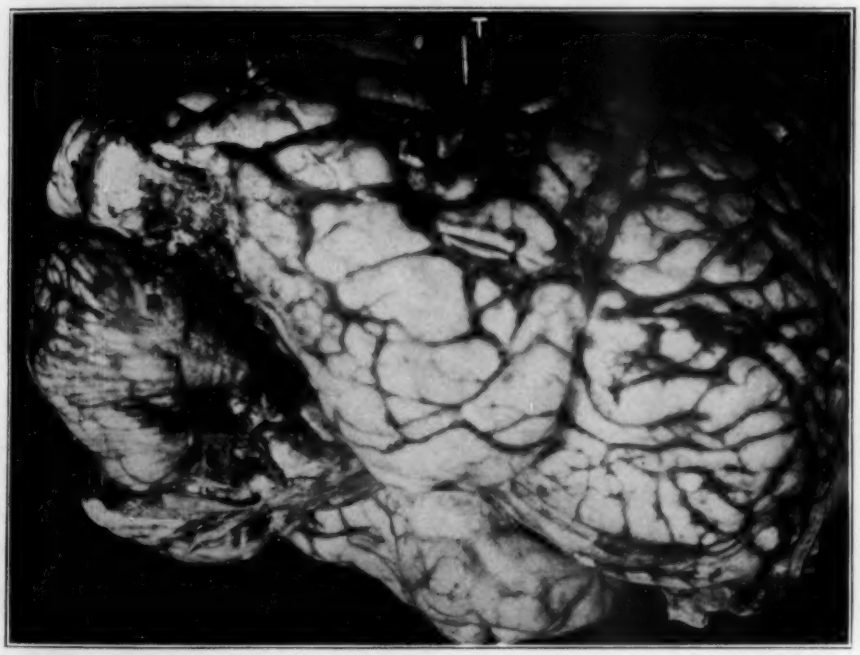

Fig. 12 (case 5).—Photograph of the brain, showing the tube (*T*) in situ.

In his monograph on abscess of the temporal lobe, Brunner emphasized the significance of the part that pneumococcus III plays in the acute cases by its marked tendency toward the destruction of bone. The cessation of discharge and the onset of postauricular pain that radiated to the right eyeball were evidences of early meningeal irritation, although there were no gross manifestations of meningeal involvement at the time of operation. Following the complete exenteration of the mastoid, there was evidently a continuation of the necrosis of the bone in the petrous pyramid, particularly along the supralabyrinthine cells toward the superior posterior margin where a localized abscess in the bone was formed.

This was followed by the formation of an extradural, an intradural, and finally an intramedullary, abscess. This case also emphasized the importance of the rule laid down by Körner; namely, that an otogenic abscess of the brain is in the immediate vicinity of the diseased bone. At the time of exploration for an abscess in the temporal lobe, the dura appeared to be under considerable tension; it was pulseless and bulged into the antrum. However, since the diagnosis was not fully established, it was deemed advisable to explore the brain through a clean trephine opening. The abscess was found at a short distance from the inferior margin of the temporal lobe, that is, near the roof of the antrum. The rubber drain had to be inserted for a considerable distance to reach the cavity of the abscess, and consequently had to drain upward (fig. 11). Better drainage undoubtedly would have been established if entrance to the abscess had been made through the original mastoid wound. Whether or not this procedure would have altered the final outcome is questionable. Eagleton, however, pointed out the surgical importance of the determination of the route of infection. He maintained that exploration and drainage through the original route results in the largest proportion of recoveries.

SUMMARY

Five consecutive cases of otitic abscess of the brain, three in the temporal lobe and two in the cerebellum, were studied to determine the routes of infection from the middle ear to the substance of the brain and, whenever possible, to correlate the clinical with the pathologic observations. Whereas the infectious process in the petrous pyramid and the dura was studied histologically at some length, its course from the meninges to the brain was given less consideration. Although it is well established that abscess of the brain is more prevalent following chronic than acute suppuration of the middle ear, it may be coincidental. Nevertheless, it is interesting that four of the five cases were acute or subacute, and that one was chronic (according to histologic evidence). In four cases the routes of infection could be determined with more or less accuracy; in one case it was most difficult, and the decision was made only by the process of elimination; it was therefore speculative. In four of the cases the infection spread by direct extension through the bone to reach the middle or posterior fossa; in all probability, in the fifth case the route was by way of the blood stream or the lymphatics. In two cases the infection reached the middle fossa through the tegmen tympani and antri (in one of which it extended up to the root of the zygomatic process); in the other two, the course was along the perilabyrinthine cells. In not one of the five cases was the labyrinth

involved. That the labyrinth is seldom involved in abscess of the brain complicating acute infection of the middle ear is an observation that coincides with the literature.

Although no definite conclusions can be drawn from so small a series of cases, the impression gained is that the pathologic changes in the petrous pyramid are in no way characteristic of abscess of the brain. Similar changes and similar routes of infection have been noted in cases of osteitis that have terminated in meningitis or in the other intracranial complications. As to what underlying factors are responsible for the production of an abscess of the brain in one case and meningitis in another is a question that remains unanswered.

THE BASEMENT MEMBRANE IN THE MUCOSA OF THE UPPER RESPIRATORY PASSAGES*

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BOSTON

Thickening of the basement membrane is one of the most striking pathologic changes seen in the mucous membrane of the respiratory tract. The basement membrane usually consists of a very thin, well defined, homogeneous membrane lying against the under surface of the epithelium. It is often but not always present, and may occur wherever there is epithelium. The mucous membrane of the respiratory tract is similar throughout, consisting of a loose connective tissue lamina propria beneath pseudostratified columnar ciliated epithelium (fig. 1.). In the majority of specimens no basement membrane is visible, but frequently a definite hyaline-like line is present beneath the epithelium (fig. 2). Sometimes this basement membrane is considerably thickened, and occasionally enormously thickened, exceeding the thickness of the overlying epithelium, and amounting to 100 or even 150 microns (fig. 3). So far as I have been able to learn, such a change occurs nowhere else in the body. Little has been written in the English language concerning this unusual pathologic picture, except to mention its occasional occurrence. Considerably more has been written concerning it in German, and an excellent summary of this literature is found in the "Handbuch der Hals-Nasen-Ohren-Heilkunde" by A. Denker and O. Kahler. About a dozen authors are mentioned as having written on the subject, the principal one being Schiefferdecker. The important facts are briefly as follows:

The epithelium of the respiratory tract lies on a basement membrane which is present only where there is columnar epithelium. It is exceedingly variable, in one place reaching a thickness of 10 microns in normal mucous membrane, in another place dwindling until it disappears entirely. In hypertrophic mucous membrane, it may be considerably thicker than normal, reaching 20 microns in thickness. A further peculiarity are fine canaliculi which traverse the membrane and are continuous with the tissue spaces of the underlying connective tissue, and which sometimes contain leukocytes wandering through.

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* Submitted for publication, Oct. 4, 1930.

* This study was undertaken at the suggestion of Dr. H. P. Mosher, in whose laboratory at the Massachusetts Eye and Ear Infirmary the work was carried out.

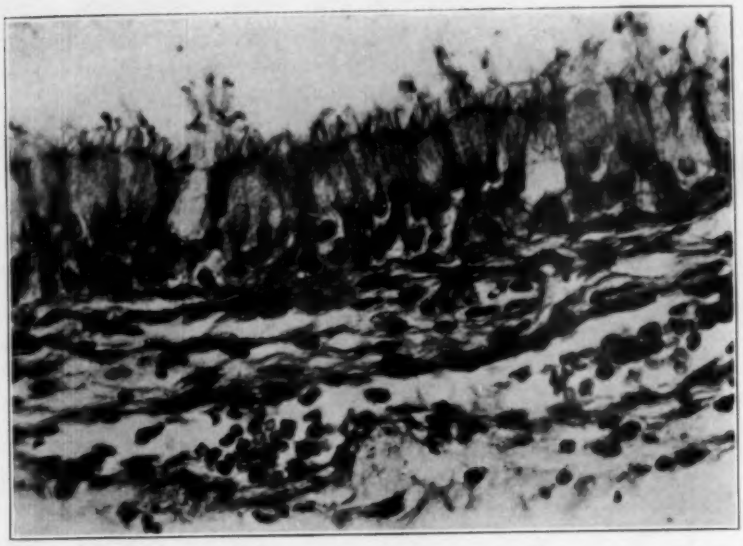

Fig. 1.—Normal respiratory mucous membrane from a normal ethmoid. Note the absence of a basement membrane. Hematoxylin and eosin stain.

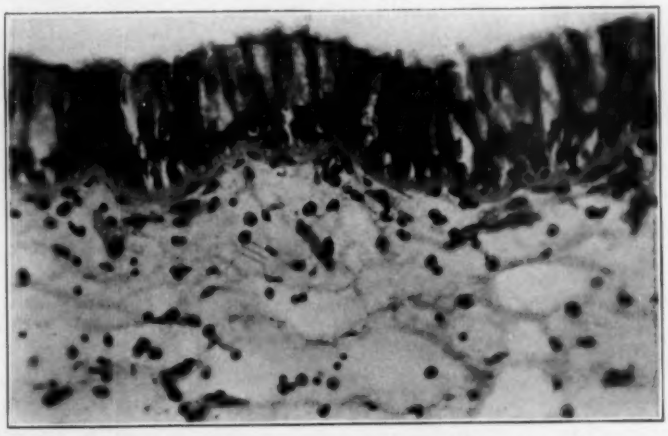

Fig. 2.—Definite thin basement membrane beneath normal epithelium, from the antrum of a case of chronic maxillary sinusitis. Hematoxylin and eosin stain.

Probably these canaliculi furnish channels for the tissue fluids to reach the surface of the epithelium. The basement membrane originates in connective tissue, as indicated by its taking the connective tissue stain, and by the fact that bundles of connective tissue enter it, while the canaliculi are continuous with the tissue spaces. Elastic fibers never penetrate it, but only lie close to its under surface. It can become considerably thickened in pathologic states.

The account in the Handbuch concludes with the statement: "One gets the impression that it acts like a hyaline degeneration of the superficial connective tissue layer of the mucous membrane in which the con-

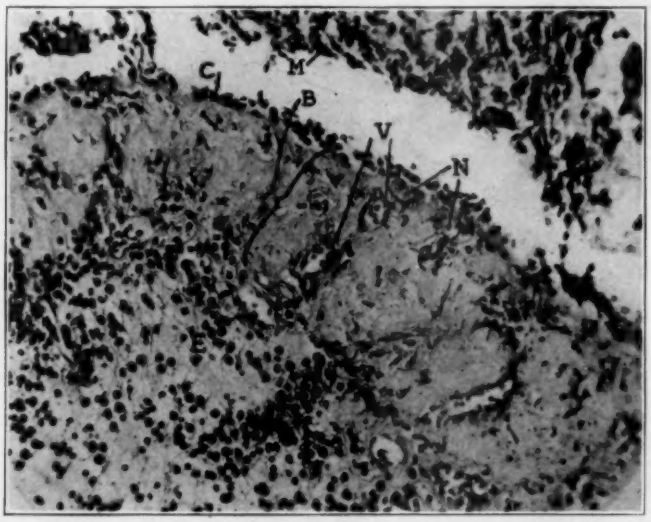

Fig. 3.—Enormously thickened basement membrane, from the antrum of an asthmatic patient, containing many elongated nuclei of migrating eosinophils. *M* indicates mucus mixed with desquamated epithelium and eosinophils; *C*, basal layer of epithelial cells; *B*, basement membrane 150 microns thick; *N*, nuclei of migrating eosinophils; *E*, eosinophils; *V*, capillaries. Hematoxylin and eosin stain.

nective tissue bundles going to join the basement membrane lose their fibrillary character and take the same homogeneous quality as the membrane itself. The remaining tissue spaces may persist in the form of canaliculi . . ."

In this account of the basement membrane, little is said about when and where this thickening occurs, whether it is related to any particular clinical condition, or to what it is due. The present study was undertaken to attempt to answer these questions, and to study the structure of the membrane.

EXPERIMENTAL DATA

All of the slides of routine pathologic specimens that have been run through the Mosher Laboratory at the Massachusetts Eye and Ear Infirmary were available for this study. Since the laboratory was founded twenty-one months ago, 1,148 different specimens from operations have been examined. Excluding tumors and a rare case of tuberculosis, 567 consisted of mucous membrane from some part of the respiratory tract. The slides of some of these were unsatisfactory for this study because they showed little or no epithelium, owing to the way the section was cut, to trauma during the operation or to the disease itself. There remained 440 slides, each from a different specimen and in most cases from a different patient. From about a fifth of the patients, two and occasionally three specimens were taken, as for example from the antrum and the ethmoid. Fifty-four per cent were from the antral mucous membrane, 10 per cent from aural polypi (included because the same epithelium lines the middle ear and the respiratory tract), 9 per cent from ethmoidal mucous membrane and the remainder from the frontal sinus (6 per cent), sphenoid sinus (0.5 per cent), septum (2 per cent), turbinates (7 per cent), nasal polypi (4 per cent), pharynx (0.25 per cent), and bronchi (1 per cent).

Ten of the specimens showing varying degrees of thickening of the basement membrane were stained with Mallory's connective tissue stain and the Verhoeff elastic tissue stain in addition to the routine hematoxylin and eosin stain. In every specimen the basement membrane took the connective tissue stain, and in no slide were elastic tissue fibers present in this membrane. The structure of the basement membrane stood out sharply with the connective tissue stain. In a few cases it was an even, sharply defined border beneath the epithelium, but more often, particularly when tremendously thickened, it was an irregular structure with processes extending down into the underlying connective tissue, and not so sharply defined from it (fig. 4). The basement membrane always contains narrow spaces or canals leading to the epithelial surface and continuous with the tissue spaces of the subjacent loose connective tissue (fig. 5). These spaces, especially where the membrane is greatly thickened, contain elongated, snakelike nuclei of leukocytes worming their way through to the surface (figs. 3 and 6). During life the leukocytes are constantly in ameboid motion, particularly the polymorphonuclear leukocytes which are never round in vitally stained preparations of blood, but show long pseudopodia extending now in one direction, now in another. At death the leukocytes assume a spherical shape, as they are seen ordinarily in sections. In the canaliculi of the basement membrane, however, they are caught in a narrow

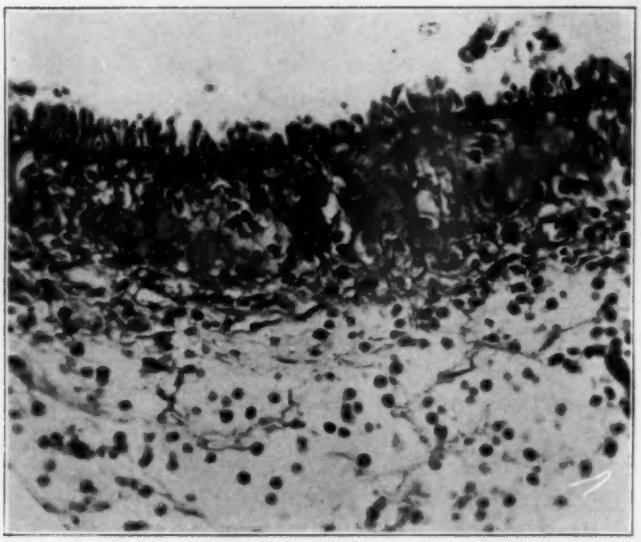

Fig. 4.—Structure of basement membrane, from the antrum of an asthmatic patient. Mallory's connective tissue stain. Against the epithelium the membrane is the densest and appears homogeneous.

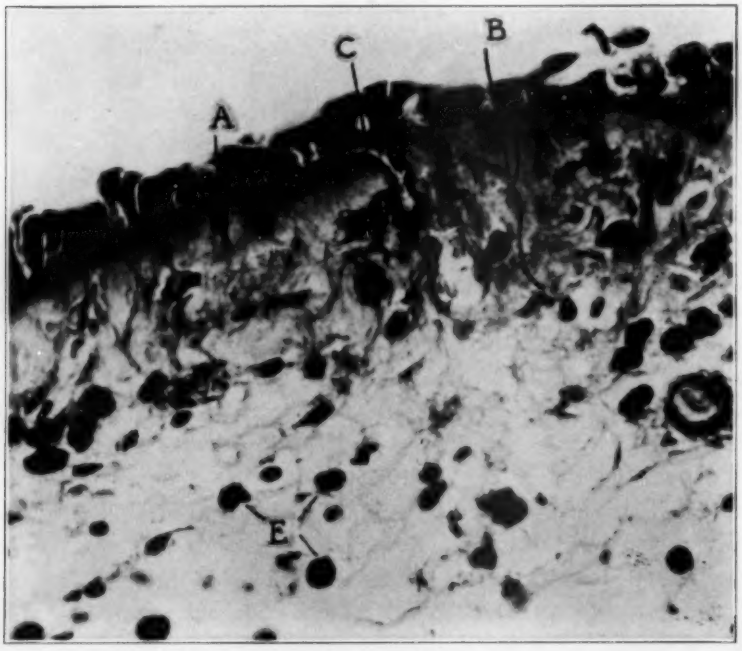

Fig. 5.—Canaliculi through the basement membrane, from the antrum of an asthmatic patient. *C* indicates a canaliculus; *B*, basement membrane; *A*, basal layer of epithelial cells; *E*, eosinophils. Note how the homogeneous upper half of the basement membrane gradually changes to a fibrillary structure, which is continuous with the loose connective tissue of the lamina propria.

passage and cannot contract. When eosinophilic infiltration of the lamina propria is marked, eosinophilic granules are seen at the ends and sides of these long nuclei, denoting them as eosinophils.

The basement membrane itself is densest; that is, it stains the darkest, immediately against the epithelium (fig. 5). As it extends downward from the epithelium it changes to a more fibrillary structure. Processes of the homogeneous material reaching down into the connective tissue beneath finally end in fibrils which are clearly continuous with the connective tissue bundles of the lamina propria (fig. 4). Capillaries are found between many of the processes. This structure, as

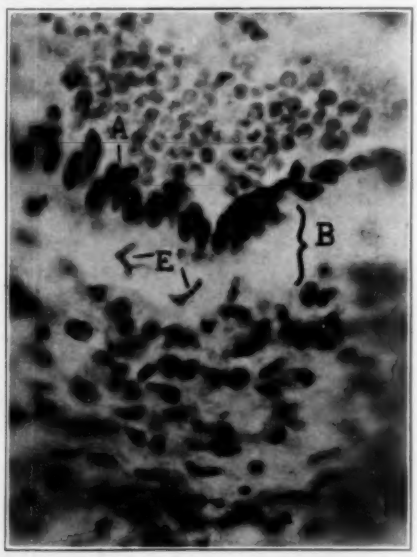

Fig. 6.—Migrating eosinophils. *A* indicates the basal layer of epithelial cells; *B*, basement membrane; *E*, elongated nuclei surrounded by eosinophilic granules. From the maxillary sinus of an asthmatic patient. Hematoxylin and eosin stain.

revealed by the connective tissue stain, together with the fact that it takes the stain, shows that the basement membrane is composed of connective tissue. It evidently consists of a dense deposition of collagen (connective tissue material) immediately beneath the epithelium, and is densest next to the epithelium.

This description agrees essentially with that of the German authors, with several exceptions. In the first place, several of my slides with stratified squamous epithelium show a definite basement membrane (fig. 8), so that the statement in the Handbuch that ". . . a basement membrane is present only where there is columnar epithelium" is

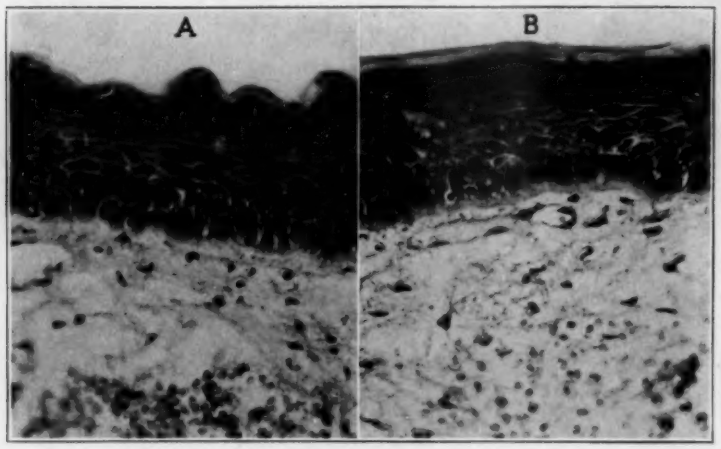

Fig. 7.—Basement membrane beneath stratified squamous epithelium. A section from the vocal cord, showing no basement membrane in one area (*A*), and a definite basement membrane in another area (*B*).

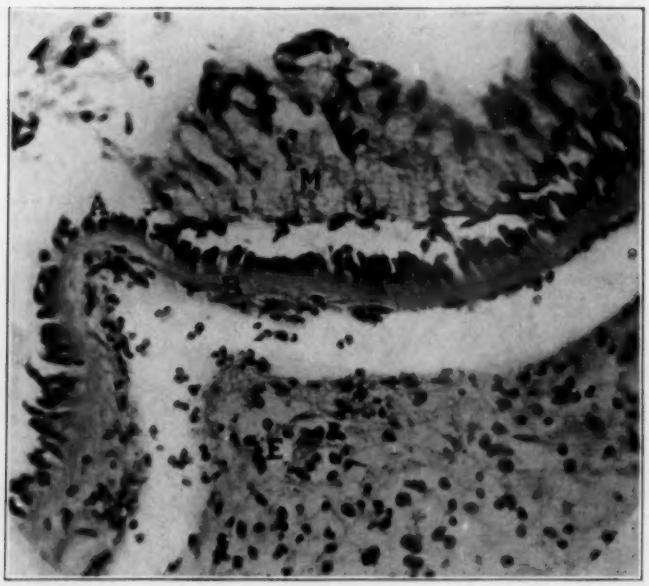

Fig. 8.—Excessive production of mucus associated with desquamation of the epithelium. *M* indicates desquamating epithelial cells filled with mucus; *A*, basal layer of cells; *B*, basement membrane; *E*, eosinophils. From the antrum of an asthmatic patient. Hematoxylin and eosin stain.

not strictly correct. In the second place, the term "hyaline degeneration" is unsatisfactory, since it does not refer to any definite pathologic process, and since there is no evidence of actual degeneration in the basement membrane, with necrosis or signs of beginning necrosis. It seems better to consider the basement membrane as a layer of collagen deposited in one homogeneous mass rather than in the usual form of delicate or coarse fibers.

To attempt to answer the questions of how often and where in the respiratory tract thickening of the basement membrane occurs, whether it is related to any particular clinical condition or to any pathologic picture in the mucous membrane, and to what it is due, the slides were classified into five groups, according to the thickness of the basement membrane. In a single slide this might vary greatly at different points in the epithelium, in which case the slide was classified according to the thickest point in the basement membrane. When no definite

TABLE 1.—*Incidence of Thickening of the Basement Membrane*

Total slides studied	440	
No basement membrane	271	62% of total
1 plus basement membrane	85	19% of total
2 plus basement membrane	55	12% of total
3 plus basement membrane	21	5% of total
4 plus basement membrane	8	2% of total

hyaline-like line could be seen between the epithelium and the lamina propria, the basement membrane was called absent. When a definite line was present, from 5 to 10 microns thick, the basement membrane was called 1 plus, (fig. 2); from 10 to 25 microns, 2 plus (fig. 8); from 25 to 50 microns, 3 plus, (figs. 4 and 5), and more than 50 microns, 4 plus (fig. 3).

For each slide the clinical diagnosis, the duration of the illness, the age of the patient, the degree of edema, fibrosis, infiltration of the lamina propria with lymphocytes and plasma cells and infiltration with eosinophils and the appearance of the epithelium were recorded. In regard to the latter it was noted whether the epithelium was the normal columnar type of the respiratory tract, whether it had changed to a transitional type where the top layer of cells began to be flattened, or whether it had changed to a stratified squamous epithelium. Excessive production of mucus by the epithelium was noted when present, and the degree of desquamation of the epithelium was recorded. The following tables were compiled from these data.

From table 1 it will be noted that nearly two thirds (62 per cent) of the slides showed no visible basement membrane, and that marked thickening occurred in only 2 per cent.

Table 2 shows that thickening of the basement membrane can occur anywhere in the respiratory tract, including the middle ear, and there is a suggestion that it is more likely to occur in the septum, turbinates, ethmoids and naso-antral wall than in the maxillary or frontal sinus or in the middle ear; in other words, it is more liable to occur in the more exposed areas.

Only twenty-seven slides of normal mucous membrane were available: a few of them were from operative specimens, the rest were

TABLE 2.—*Localization of Thickening of the Basement Membrane*

	No Basement Membrane, per Cent	1 Plus Basement Membrane, per Cent	2 Plus Basement Membrane, per Cent	3 Plus Basement Membrane, per Cent	4 Plus Basement Membrane, per Cent
Antrum	56	40	75	48	75
Aural polyp	14	7	0	0	0
Ethmoidal sinus	6	15	8	19	0
Turbinates	2	19	11	13	0
Frontal sinus	8	4	0	0	0
Nasal polyp	5	3	3	0	0
Naso-antral wall	½	7	3	14	0
Lacrimal sac	4	1	0	0	0
Septum	1	3	0	5	25
Bronchi	1	0	0	0	0
Pharynx	½	0	0	0	0

TABLE 3.—*Clinical Diagnosis in Each Group*

	No Basement Membrane, per Cent	1 Plus Basement Membrane, per Cent	2 Plus Basement Membrane, per Cent	3 Plus Basement Membrane, per Cent	4 Plus Basement Membrane, per Cent
Chronic sinusitis	64	61	67	75	50
Asthma	6	12	25	25	50
Chronic suppurative otitis media	19	2	0	0	0
Acute sinusitis	5	5	0	0	0
Vasomotor rhinitis	1	2	4	0	0
Chronic dacryocystitis	2	2	4	0	0
Others	3	16	0	0	0

removed at autopsy. Seven of these showed a definite though thin basement membrane, classed as 1 plus. Although 75 per cent of these showed no basement membrane, conclusions cannot be drawn from so small a series, except to say that a basement membrane can be present in normal-appearing mucous membrane.

Table 3 indicates a striking association between asthma and thickening of the basement membrane, so that only 6 per cent of the patients without a basement membrane had asthma, while 50 per cent of the patients with marked thickening of the basement membrane gave a history of having had asthma. Possibly if the histories in cases of chronic sinusitis were taken with this in mind, the association would

be even more marked. There were, in all, twenty-four cases of asthma, two thirds of which showed some thickening of the basement membrane.

As shown by table 4, of the slides in which a basement membrane was not seen, eosinophils were absent in 36 per cent and present in 3 per cent; of the slides showing markedly thickened basement membrane, there were as many with as without eosinophils. In other words there is a distinct though slight tendency for thickening of the basement membrane and eosinophilic infiltration to be associated.

From table 5 it is seen that normal, intact epithelium was found in 89 per cent of slides showing no basement membrane and in none

TABLE 4.—*Degree of Eosinophilic Infiltration in Each Group*

	No Basement Membrane, per Cent	1 Plus Basement Membrane, per Cent	2 Plus Basement Membrane, per Cent	3 Plus Basement Membrane, per Cent	4 Plus Basement Membrane, per Cent
No eosinophils	36	22	25	9	12
Few eosinophils	28	32	22	24	25
Moderate eosinophils	24	22	14	24	25
Many eosinophils	9	16	14	24	25
Very many eosinophils	3	8	25	19	12

TABLE 5.—*Degree of Epithelial Desquamation in Each Group*

	No Basement Membrane, per Cent	1 Plus Basement Membrane, per Cent	2 Plus Basement Membrane, per Cent	3 Plus Basement Membrane, per Cent	4 Plus Basement Membrane, per Cent
No desquamation of epithelium	89	41	17	6	0
Slight desquamation	6	18	9	6	0
Moderate desquamation	4	17	20	38	12
Marked desquamation	0.5	20	38	31	25
Very marked desquamation	0.5	3	15	19	63

of the slides with a markedly thickened basement membrane, while complete desquamation of the epithelium was present in only 0.5 per cent of the slides without a basement membrane and in 63 per cent of the markedly thickened basement membranes. Evidently thickening of the basement membrane and desquamation of the epithelium are associated to a marked degree, and, moreover, the amount of thickening is roughly proportional to the degree of desquamation. An additional fact noted during the examination of the slides was that when in the same slide the basement membrane was thickened in one place and absent in another, the epithelium was usually normal in the latter and desquamating in the former.

From table 6 it is seen that there is a slight tendency for the excessive formation of mucus to be associated with a thickened basement

membrane, while squamous epithelium tends to be associated with absence of the basement membrane.

The tabulations for edema, fibrosis and infiltration of lymphocytes and plasma cells are not included here, since they showed no significant differences between patients with and those without thickening of the basement membrane. The ages of the patients and the duration of their illnesses were likewise tabulated, and though they suggested that increased age and long duration of the symptoms predispose to a thickened basement membrane, the differences were not sufficient to enable one to draw definite conclusions.

To confirm these observations, a series of 125 slides from 25 asthmatic patients was examined, and the results were tabulated. These slides were lent to me by Dr. F. L. Weille from his collection showing pathologic changes of the mucous membrane in patients with asthma. From each of his patients, 6 or more specimens were taken, usually

TABLE 6.—*Number of Slides Showing Excessive Formation of Mucus, Transitional Epithelium and Stratified Squamous Epithelium, in Each Group*

	No Basement Membrane, per Cent	1 Plus Basement Membrane, per Cent	2 Plus Basement Membrane, per Cent	3 Plus Basement Membrane, per Cent	4 Plus Basement Membrane, per Cent
Forming excessive mucus.....	3	35	15	19	12
Transitional epithelium.....	12	20	15	37	25
Stratified squamous epithelium..	12	7	15	0	0

including some from the naso-antral wall, the inferior or middle turbinate and the ethmoid and several from different parts of the antrum. Most of these patients, like those in the first group analyzed, showed evidence of infection in the antrum and ethmoids, together with the asthma. Of the 125 slides, 29 per cent showed no basement membrane; 36 per cent showed 1 plus thickening; 26 per cent, 2 plus thickening, 7 per cent, 3 plus, and 2 per cent, 4 plus. In other words, about two thirds of the asthmatic tissues showed a definite basement membrane, which is the same proportion as that found in the 24 asthmatic tissues of the first group.

Tables 7, 8, 9 and 10 are similar in each case to those of the first group analyzed, and confirm the conclusions drawn from the first group. In comparing tables 4 and 8, it is evident that in general there is a higher proportion of eosinophils in the cases of asthma than in the first group.

TABLE 7.—*Tissue in Each Group* *

	No Basement Membrane, per Cent	1 Plus Basement Membrane, per Cent	2 Plus Basement Membrane, per Cent	3 Plus Basement Membrane, per Cent	4 Plus Basement Membrane, per Cent
Antrum	55	22	30	89	100
Ethmoid	6	13	12	0	0
Naso-antral wall	3	15	18	11	0
Turbinate	11	25	22	0	0
Others	25	25	18	0	0

* Compare with table 2.

TABLE 8.—*Eosinophilic Infiltration in Each Group* *

	No Basement Membrane, per Cent	1 Plus Basement Membrane, per Cent	2 Plus Basement Membrane, per Cent	3 Plus Basement Membrane, per Cent	4 Plus Basement Membrane, per Cent
No eosinophils	33	16	9	0	0
Few eosinophils	17	27	18	11	0
Moderate eosinophils	20	42	34	11	0
Many eosinophils	20	13	24	11	0
Very many eosinophils	10	2	15	67	100

* Compare with table 4.

TABLE 9.—*Formation of Mucus and Transitional Epithelium in Each Group* *

	No Basement Membrane, per Cent	1 Plus Basement Membrane, per Cent	2 Plus Basement Membrane, per Cent	3 Plus Basement Membrane, per Cent	4 Plus Basement Membrane, per Cent
Excessive formation of mucus	22	24	30	44	50
Transional epithelium	22	7	9	0	0

* Compare with table 6.

TABLE 10.—*Epithelial Desquamation in Each Group* *

	No Basement Membrane, per Cent	1 Plus Basement Membrane, per Cent	2 Plus Basement Membrane, per Cent	3 Plus Basement Membrane, per Cent	4 Plus Basement Membrane, per Cent
No desquamation of epithelium	72	38	12	11	0
Slight desquamation	6	20	12	11	0
Moderate desquamation	22	16	27	11	0
Marked desquamation	0	17	30	11	0
Very marked desquamation	0	9	9	56	100

*Compare with table 5.

To sum up, a distinct basement membrane can occur anywhere in the respiratory tract, but it is more liable to be found in exposed areas. It is sometimes seen in normal-appearing mucous membrane. In various inflammations, chiefly chronic, it was present in a third of the cases. It is associated with eosinophilic infiltration and the excessive formation

of mucus by the epithelium, to a slight extent. There is a marked association between desquamation of the epithelium and thickening of the basement membrane.

The questions that now naturally come to mind are: Why should the basement membrane be thickened in one area and absent in another? Why is basement membrane frequently found in asthma? What causes the enormous thickening occasionally seen? In short, what causes collagen to be deposited against the epithelium?

Answers to these questions are suggested by the association of the basement membrane with desquamation of the epithelium. In carcinoma the hardness is due more to an accompanying increase in connective tissue than to tumor cells. The slow growing squamous cell carinoma of low malignancy, in which the tumor cells approach normal epithelial cells in appearance, particularly stimulates the deposition of collagen and consequently is stony hard. The inference is that abnormally active or rapidly growing epithelial cells can stimulate the adjacent connective tissue cells to deposit collagen. Wherever marked thickening of the basement membrane is found, there is usually evidence of abnormal activity or growth of the epithelial cells, shown by desquamation, often with an excessive production of mucus (figs. 3 and 8). The structure of the basement membrane itself, which is densest next to the epithelium, suggests that it results from an epithelial stimulation of the adjacent connective tissue cells.

The frequent occurrence of a basement membrane in cases of asthma can be accounted for by repeated epithelial stimulations with excessive production of mucus and epithelial desquamation, as well as by the chronicity and long duration of the illness. When the basement membrane is thickened in one place and absent in another, there has probably been an epithelial irritation in one area and not in the other; for example in the exposed areas of the nose, where a thick basement membrane is more frequently encountered than in the accessory sinuses. The association with eosinophilic infiltration is probably due to the association with asthma.

This hypothesis of the formation of the basement membrane and the observations in this study incline one to believe, contrary to the German writers, that normally there is no basement membrane in the mucous membrane of the respiratory tract, and that when one is present it is due to a long-standing or repeated epithelial irritation, usually the result of infection or asthma, the abnormally active epithelial cells in turn having stimulated the subjacent connective tissue cells, with the gradual accumulation of a basement membrane.

SUMMARY

A definite basement membrane beneath the epithelium may be found anywhere in the respiratory tract. While it may be seen in normal-appearing mucous membrane, it is probably evidence of a chronic epithelial irritation in the past. It usually occurs beneath pseudostratified columnar ciliated epithelium, but may occur with the transitional form and occasionally with stratified squamous epithelium. It is composed of a dense, more or less homogeneous layer of collagen beneath the epithelium, and is interspersed with canaliculi through which leukocytes migrate to the surface, and perhaps tissue fluids escape to the surface. It is found in about a third of the specimens from chronic inflammations, and in about two thirds of the specimens from asthmatic patients. When greatly thickened, it is accompanied by a desquamating epithelium, often producing mucus excessively. This suggests that the presence of a basement membrane results from stimulation of connective tissue cells by abnormally active epithelium. Since edema, fibrosis and cellular infiltration of the lamina propria are not more marked when there is a thickened basement membrane, it has no clinical or pathologic significance other than being an evidence of chronic epithelial irritation, past or present.

CONGENITAL ATRESIA OF THE POSTERIOR NARES *

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Clinically, the term "atresia" (imperforation) is not applied in its strictest sense, but under this term are commonly included also those cases of congenital occlusion in which there is a minute perforation sufficient to admit a small probe. One may not, however, include under the title "atresia" any further cases in which the choanae are narrowed, or in which there is asymmetry of the posterior nares.

The atresia may be bilateral or more commonly unilateral. It may be caused by a membranous, membrano-osseous or purely osseous formation. It has not been proved to be transmissible and has no preference for either sex.

This article originated in the occurrence of two cases (in sisters) of bilateral congenital atresia encountered in my practice at the Deaconess Hospital, Edinburgh. Such cases are rare, and in order to make this article more comprehensive six cases of unilateral congenital atresia are also included. The latter occurred in the Ear, Nose and Throat Department of the Royal Infirmary of Edinburgh, when it was under the charge of Dr. A. Logan Turner and presently under the charge of Dr. J. S. Fraser (to both of whom I am indebted for the use of the case records). In the statistical tables of this department, I noted that in a period of twenty years (1907-1926, inclusive) of 27,863 cases of diseases of the nose and its adjoining sinuses there were 6 cases (0.02 per cent) of unilateral atresia of the choanae and not a single case of bilateral atresia.

EMBRYOLOGY

As the subject under consideration is essentially developmental in origin, one must of necessity have recourse to a detailed description of the formation of the nose and, in a lesser degree, the mouth, from the earliest period onward, in order to determine the sequence of events and so arrive at a possible solution of the occurrence of the entity.

It is interesting to note that Keith [1] pointed out that in the evolution of the face of the human embryo, there are three stages: (1) a "piscine" stage in which the nose and mouth are formed independently; (2) an

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* From the Ear and Throat Department of the Royal Infirmary, Edinburgh, under the charge of Dr. J. S. Fraser.

1. Keith, Arthur: Human Embryology and Morphology, ed. 4, London, Edward Arnold, 1921, chap. 12, p. 159.

"amphibian" stage in which the nasal respiratory passage opens directly onto the roof of the mouth and (3) a "mammalian" stage in which the nasal respiratory passage opens into the nasopharynx.

The first structure that I shall discuss is the buccopharyngeal membrane which separates the stomodeum (primitive mouth) from the foregut. This membrane, which is composed of ectoderm on its outer or external surface and entoderm on its inner or internal surface, is normally broken down and disappears during the third week of fetal life. By this process the stomodeum and foregut become continuous.

Another membrane that is analogous to the one mentioned is the anal membrane, which shuts off the proctodeum from the hindgut. It should disappear at the beginning of the fourth week.

Before the buccopharyngeal membrane breaks down the cephalic extremity of the foregut dilates to form the primitive pharynx. Pouches then appear in the primitive pharynx, five (branchial) on each lateral wall, two ventrally and one dorsally (Seessel's).

The dorsal pouch is formed immediately caudad to the dorsal end of the buccopharyngeal membrane. From the position of this dorsal pouch can be judged the position of the buccopharyngeal membrane. External to the primitive pharynx a series of clefts is formed which coincide in position to the pouches so that the tissue left between the invaginations on both sides remains in the form of arches (branchial arches). From the first arch is formed the external auricles, the external acoustic meatus, the tympanic cavity and the eustachian tube, tissues derived from entoderm.

One can thus trace the position of the buccopharyngeal membrane from the foregoing information. It lies dorsal to or above the orifices of the eustachian tube; hence the full development and healthy state of ears recorded in case 1.

During the third week of intra-uterine life, the nose commences to develop. This is indicated by the appearance of olfactory laminae which are invaginated into the forebrain in a recess or hollow called the olfactory fossa, which is open to the surface. At this stage the fossa is situated at some distance from the primitive mouth. The olfactory laminae give origin to the lateral and medial nasal processes. The lateral nasal processes are dorsal to the median nasal process, so that the olfactory fossa is directed somewhat laterally. The medial nasal process gives rise to two outgrowths at its lower free margin, called the globular processes. It is perhaps appropriate to state at this point the tissues to which these nasal processes give rise. The median nasal process forms the septum of the nose, the premaxilla and the middle third of the upper lip, while the lateral nasal processes give rise to the cribriform plate of the ethmoid, the lateral mass of the ethmoid (supe-

rior and middle conchae), the inferior concha and the lacrimal and nasal bones.

Before continuing, another facial process must be considered, namely, that of the superior maxilla, an off-shoot from the process of the mandibular arch. This process grows medially, to reach and fuse with the globular process, thus closing the primitive nasal cavity antero-inferiorly. It also fuses at this time with the lateral nasal processes and takes part in the formation of the lateral nasal wall.

The olfactory fossa can now be described as a blind tube, separated into halves by the mesial nasal process, which opens externally onto the surface of the face. This tube rapidly makes its way toward the roof of the mouth, its progress not being due to an invagination of the sensory epithelium but to the growth of the nasal processes.

Eventually the olfactory tube is separated from the mouth only by a thinned out membrane, the nasobuccal membrane, which breaks down and normally disappears at the end of the sixth week. When this occurs the olfactory fossa is converted into a primitive nose, having an external opening, the vestibule and a posterior opening called the primitive choanae, and, of course, the separating partition, the septum. At this stage, the floor is formed by the premaxilla, a derivative of the globular process. Posteriorly, the primitive choanae stretch upward to the base of the sphenoid as long narrow openings which are contiguous to the base of the skull. The septum (mesial nasal process) is short and thick. The dimensions of the primitive nasal cavities are naturally very small. The next developmental stage will complete the fully formed nasal cavities. It is initiated by a growth medialward and to a slight extent in an anterior direction from the palatal process of the maxilla and a downward and backward growth of the nasal septum, which is thinned out in the process. Apparently the growth of the palatal process of the maxilla medialward is not influenced by either the retention or the breaking down of this membrane (nasobuccal); cleft palate results when the nasobuccal membrane does break down. I am not aware of any case of choanal atresia in which the hard palate did not consist entirely of bone.

The palatal processes fuse anteriorly with the premaxilla. During the fusion, a foramen is formed in mammal skulls, which is situated in the nose close to the organ of Jacobson, an implant of sensory olfactory epithelium on the septum. In human beings vestiges called the nasopalatine foramen remain.

The growth of the palatal portions of the maxillary processes continues until they meet in the midline, when they fuse firmly with one another and also with the vomer.

This formation of the fully formed palate completes the floor of the nasal cavities. Looking back it is seen that in the rudimentary nasal

cavity the floor was completed by the premaxillary process, but in the next stage of growth, by the backward displacement of the nasal septum, the floor again was deficient and in contact with the tongue.

It can thus be seen that the primitive or rudimentary choanae are separate structures and should not be confused with the secondary or fully formed choanae.

When fully formed, the choanae are bounded superiorly by the body of the sphenoid and the alae of the vomer, inferiorly by the fusion of the soft and hard palates, laterally by the medial plates of the pterygoid processes and mesially by the posterior border of the septum, which is structurally composed of the vomer and perpendicular plate of the ethmoid bone.

The choanae are not set in the vertical plane but in a somewhat oblique axis.

UNILATERAL ATRESIA OF THE CHOANAE

There were six cases, all of which occurred in the ear and throat department of the Royal Infirmary, Edinburgh. The sexes were equally represented. The oldest patient examined was 45 and the youngest, 9 years of age. This age incidence does not, of course, indicate the onset of the condition, but the period at which the patient sought treatment. No history of relatives suffering from the same condition was obtained from any of the patients. The right side was affected in four, and the left side in two, cases. This agrees with the observation of other investigators that the right choanae is the more commonly affected. In all of the cases the determination of the occlusion was membrano-osseous. On anterior rhinoscopy, the affected side contained a profuse discharge of white mucus. The septum was deviated to the side of the atresia in four cases and to the nonatresic side in one case, and in the remaining case the septum was straight. In three cases special note was taken of the inferior conchae which were hypertrophied on the affected side. In the youngest patient, a foreign body (a cherry stone) was present in the obstructed nostril.

Posterior rhinoscopy was performed in three cases and digital examination of the nasopharynx in every case. In one of the cases the choana was found to be absent and replaced by a hard bony plate in which there was a small depression in the upper and inner quadrant. A probe pushed through from the front of the nose passed through an aperture on the occlusion at this depression.

Adenoids were absent in all of the cases; one patient gave a history of removal of the adenoids years before at another hospital.

The drumheads on the affected side were normal, while in two cases chronic suppurative otitis media was present on the nonobstructed side.

Half of the patients had previously been operated on elsewhere for nasal obstruction, the true condition being undiagnosed.

In three cases roentgenograms had been taken, and the air sinuses on both sides of the skull were found to be well developed. The obstructed nasal cavity appeared dull as compared with the free side of the nose.

Mention was made of asymmetry of the palate in only one case.

In two of the cases the patients refused operation, which tends to show that the condition (unilateral) does not give rise to much discomfort. The patients are not deprived of their sense of smell, although one patient, when questioned, admitted that his sense of smell was not very acute. They can also breathe fairly successfully through the one nostril. One patient died while undergoing aural treatment, and formed the subject of a communication by J. S. Fraser.[2]

The remaining three patients were operated on successfully. The procedure followed was to perform submucous resection of the septum and to continue the elevation of the mucous membrane from the bony occlusion, which was then removed. A large opening in the hitherto intact mucous membrane was then made into the nasopharynx.

The operation is difficult, as is evidenced by the fact that in two of the cases the posterior opening was made through the posterior end of the septum, and the bony occlusion was left in situ. The functional result, however, was the same, the patient being able to breathe through both nostrils.

BILATERAL ATRESIA OF THE CHOANAE

There were two cases of this condition which occurred in my clinic at the Deaconess Hospital. Both occurred in females of the same family. Before giving their case histories, it will be interesting to note the family history.

Family History.—The parents were healthy; the father was a minister of religion. There was no history of choanal occlusion on either side of the family. The eldest child (case 1) was exceptionally difficult to rear, especially for the first few days and during the first months. She was unable to feed at the breast, and had to be fed artificially by an experienced nurse. The second child, a boy, lived for only forty-eight hours. The family physician was not clear as to the cause of death. The child had attacks of dyspnea, was rather bluish and died of asphyxia. The physician thought that death was due to involvement of the lung. The third child (case 2) was fed at the breast, and was not nearly so difficult to rear as the first child. She throve quite well. The fourth child (a girl) was normal and could easily breathe through her nose. All of the births were normal and noninstrumental. The sisters were greatly attached to each other, no doubt being drawn together by the same disability. They were highly sensitive and most difficult to examine. Neither of them could bear any manipulation of the pharynx, as they secretly feared asphyxia. They were pathetic in

2. Fraser, J. S.: Congenital Atresia of the Choanae, Brit. M. J. **2**:601 (Nov. 26) 1910.

their desire to breathe through the nose and so to be like their friends. Each could "blow the nose" with some success. The procedure was somewhat as follows: they blew out their cheeks, jerked their heads forward and compressed the external nose, at the same time emitting a realistic noise from between their lips. Much was imitation, but apparently the jerk of the head tilted forward some mucus which was expressed by compression of the vestibule.

CASE 1.—F. Q., a girl, aged 18, complained of not being able to breathe through the nose. Adenoids had been removed at the age of 2. She was next operated on for nasal polypi at the age of 5 years. The parents related that the operation had been performed in their own domicile, and that the surgeon had not shown them the polypi removed at operation. The patient's tonsils and adenoids had been removed when she was 12 years old.

She had always been able to appreciate the coarser smells, e.g., eucalyptus and ammonia. She had often received presents of perfume, and had liberally sprinkled her handkerchief with it, but it might have been so much water as she could not smell it.

She could also appreciate the fundamental tastes, bitter, sweet, etc., but not the more refined ones; that is, she could not perceive a vanilla flavor.

She could sneeze, and when she did so, she had a sensation of air going into the ears.

She had never attempted to smoke, because she was afraid that she might be asphyxiated.

Examination.—The patient was well developed and of average height and weight. The face was perfectly symmetrical. On examination of the mouth, the arch of the palate was found to be very high, narrow and symmetrical. The roots of the tonsils still remained. The speech was of the rhinolalia clausa type. Posterior rhinoscopy was performed with great difficulty. No suggestion of a choana was identified; only a continuous wall of mucous membrane could be seen. The roof of the nasopharynx appeared low. The eustachian cushions and orifices appeared normal. On digital examination, no choanae were felt, only a fold of mucous membrane which could be pushed upward for a short distance. The external part of the nose was of the broad type, and there was no excoriation of the upper lip.

On anterior rhinoscopy, the inferior conchae were markedly hypertrophied, the anterior ends being like large mulberries. The septum was quite straight. The middle conchae were rather atrophied. After the removal of the anterior ends of the inferior conchae, the posterior end of the nasal cavities was seen to be shaped like the flattish prow of a boat, closed by the mucous membrane from the lateral wall of the nose, becoming continuous with the septal mucous membrane. The posterior ends of the inferior conchae (which were not hypertrophied) were carried on to the central point of the occluding partition. As stated, this occlusion was carried in an upward, backward and medial direction. There was a profuse discharge of gray translucent mucus lying posteriorly and on the floor of the nose. Under a cursory examination, it might easily have been mistaken for a polypus. Both drumheads were normal, as was the hearing. The larynx was normal. Vision was normal, and there was no suggestion of exophthalmos. The wall of the chest was well and fully developed. The expansion of the chest was very good. Menstruation was normal.

Roentgen Examination of the Skull.—Iodized poppy seed oil 40 per cent was poured into each nostril and the anterior nares plugged with absorbent cotton (figs. 1 and 2). Anteroposterior and lateral roentgenograms were then taken.

Fig. 1 (case 1).—Anteroposterior view of the skull. The nostrils are full of iodized oil, which has partially filled the ethmoidal cells. The maxillary antrums are fully developed and are free from iodized oil. The nasopharynx is quite clear, and there are no signs of iodized oil.

Fig. 2 (case 1).—Lateral view of the skull. The nostrils are filled with iodized oil. The frontal sinuses are fully developed. The sphenoidal sinus is practically filled with iodized oil. The nasopharynx is quite clear.

On the following day, similar views were taken with a sponge soaked in iodized oil which had been pushed firmly into the nasopharynx (fig. 3). The roentgenograms are self-explanatory, but attention is particularly directed to the triangular space shown in figure 3. This space has as its boundaries, superiorly and posteriorly, the floor of the sphenoidal sinus, anteriorly the bony plate forming the choanal atresia and inferiorly the remains of the buccopharyngeal membrane. This anatomic formation is present only in the greatest or most severe degree of choanal atresia. In figure 5 the triangular space is absent (compare with fig. 3).

Operation.—On Sept. 30, 1929, with the patient under chloroform and oxygen anesthesia, the nose was packed with 10 per cent cocaine and an equal amount of epinephrine. A postnasal plug, bright yellow from its impregnation with iodoform, was placed in the nasopharynx. Submucous resection of the septum was performed first. As the bony structure of the septum was followed backward, it became much thicker and harder. The mucous membrane flaps were reflected off the bony plate forming the atresia. A long chisel was used to pierce

Fig. 3 (case 1).—Lateral view of the skull. The nostrils were swabbed with iodized oil. A sponge soaked in iodized oil is present in the nasopharynx. The sphenoidal sinus is free from iodized oil. Behind the posterior border of the septum and underneath the floor of the sphenoidal sinus, a "dead space" is seen, which is free from iodized oil. This space is bounded on its inferior surface by the remains of the buccopharyngeal membrane. The air cells of the mastoid are well developed.

the bony plate. Considerable force had to be exerted in this maneuver. The opening in the plate was then enlarged with forceps for cutting bone. After breaking through the bony plate, I was nonplussed when I did not see the yellow iodoform postnasal plug. Apparently after the removal of the bony atresia there was a "dead triangular space" (fig. 3). The boundaries of this space have been elaborated. The posterosuperior surface was lined by a pale pink membrane which was without doubt periosteum. The postnasal pack was removed and the finger inserted into the nasopharynx, which was found completely shut off from the nose by a membrane that was pushed up by the finger and seen through the operation cavity. With some difficulty it was removed completely (unfortunately

no pieces of the tissue were taken for microscopic examination). At its upper end the nasopharynx was found to be somewhat narrow. In order to keep patent the opening made at the operation, the posterior third of the septum was removed in its entirety. Iodoform packing was introduced through the nose into the nasopharynx, and the whole was firmly packed.

Course.—October 2: The packing was removed. The patient was able to breathe through the nose for the first time in her life. Owing to the stretching of the soft palate at the time of operation, her voice was altered and was of the rhinolalia aperta type. The nose was douched out twice a day. She was ordered to suck the lotion back through her nose and expectorate it. An oily nasal spray was also frequently used.

October 3: The patient was able to smell a flower (a rose) for the first time, and with her eyes shut she could distinguish the scent of a chrysanthemum from that of a rose. The sense of smell returned practically at once. It was not keenly developed, but was quite good.

October 5: The airway was quite patent, and normal speech had returned, the soft palate having fully recovered.

Jan. 4, 1930: The patient reported that she could breathe freely through the nose. The posterior opening of the nose was completely healed. Daily nasal douching had been stopped.

February 28: The patient reported the condition as satisfactory.

Microscopic Report.—Microscopic sections of the inferior conchae (removed at examination) showed redundant and edematous soft tissues attached to the conchal bone. These tissues were full of dilated lymph spaces and inflammatory cells, both chronic and acute. The glands were dilated and full of secretion.

CASE 2.—F. Q., a girl, aged 15, a sister of the patient in case 1, was brought to me by her mother because the child had never breathed through her nose. On questioning, she stated that she could not distinguish the finer types of taste, but could distinguish the coarser types. She had no sense of smell. The patient could hear quite well, but often suffered from a cold in the head and sneezing. Operations had been performed on the tonsils and the adenoids at the age of 6 and again at the age of 9.

Examination.—The face was symmetrical. The palatal arch was high, narrow and symmetrical. The teeth were well formed and healthy. The patient had worn a prosthetic appliance to keep the teeth from protruding. The lower pole of the left tonsil still remained. The speech was of the rhinolalia clausa type. The nostrils were wide, and the septum was deviated to the left side but not markedly. The anterior ends of both inferior conchae were enormously hypertrophied. Posteriorly, the inferior conchae curved around to meet the posterior portion of the septum. Large blobs of mucopus were present on the floor of the nose. This material was opalescent. The middle conchae were not enlarged. There was a trace of adenoids, and no choanae could be determined on posterior rhinoscopy. On digital examination, the choanae were found to be replaced by smooth hard plates which were slightly indented. The posterior edge of the septum could also be felt. It was set at an oblique angle to the anterior wall of the sphenoidal sinus. Both drumheads were normal. The eustachian cushions were normal. The larynx was quite healthy. Vision was normal, and there was no exophthalmos. The chest was exceptionally well formed, with good expansion. Menstruation was normal.

Roentgen examination was made of the skull after the injection of iodized oil (figs. 4 and 5).

Fig. 4 (case 2).—Lateral view of the skull. The nostrils have been filled with iodized oil. The bony plate forming the choanal atresia is definite. The sphenoidal sinus is full of iodized oil. The ethmoidal cells are comparatively free from iodized oil. The frontal sinus is very large, and the air cells of the mastoid are well developed. (This is a view of the left side.)

Fig. 5 (case 2).—Lateral view of the skull. The nostrils have been filled with iodized oil and a plug soaked in iodized oil was placed in the nasopharynx. The position is not quite a true lateral, but the bony choanal atresia is particularly well seen. (This is a view of the right side.)

Operation.—On Jan. 24, 1930, with the patient under chloroform and oxygen anesthesia, the nose was packed with 10 per cent cocaine and epinephrine (equal parts), and an iodoform plug was inserted into the nasopharynx. Submucous resection of the septum was performed. The soft tissues were dissected round and off from the lower part of the anterior wall of the sphenoidal sinus and obstructing bone plates of the choanae. With a chisel and mallet a hole was made through one choanal plate, and the nasopharynx was extensively opened. The yellow iodoform plug was clearly seen. The mucous membrane of the occluding partition and that of the posterior third of the septum were removed "piecemeal." The sphenoidal sinus was accidentally opened. A little clear secretion was present in this air sinus, which was healthy. After removal of the iodoform plug, the finger was introduced into the nasopharynx, which acted as a guide for the nibbling forceps. The posterior edge of the septum was composed of exceptionally hard bone. The nasopharynx appeared to be not quite fully developed. The nasal cavities and nasopharynx were packed with iodoform gauze. The inferior conchae were left untouched so as to prevent any possibility of a "dry nose." The operation proved to be exceptionally difficult, and lasted about ninety minutes. The fragments of the choanal plates were preserved for microscopic examination.

Course.—January 26: The packing was removed from the nose and the nasopharynx. Nasal douches, and also the frequent use of an oily spray, were started. The patient could not speak properly. (Speech was of a rhinolalia aperta type owing to stretching of the soft palate at operation.) She breathed freely through the nose.

January 27: The patient had a slight rise in temperature, which did not cause great anxiety.

February 25: The temperature was now normal, and the patient felt well. She had an excellent passage through the nose. She could distinguish the various perfumes, and she stated that food tasted better, and that her appetite was therefore more keen. Speech was normal.

February 28: The patient reported satisfactory progress.

Microscopic Examination of Tissue Removed at Operation.—Sections were cut in paraffin and stained with hematoxylin and eosin. The mucous membrane was surmounted by a single layer of columnar ciliated epithelium lying on a basement membrane. The mucous membrane was thickened, fibrosed and infiltrated with a great number of small round cells, which were especially numerous immediately underneath the basement membrane. The vessels in this tissue were numerous. Their walls were thickened, and the lumen was engorged with blood cells. In parts the areas were so vascular as to resemble the cavernous type of tissue.

The glands were situated in the deeper parts of the mucous membrane. In most parts the secreting epithelium of the glands was very active. In a few localities the secretory epithelium was disintegrating and the cells showed loss of nuclei and had become granular. The fibrous tissue present in the deeper layers was loose and edematous, approximating a myxomatous type of tissue. Many of the cells were not differentiated into fibrous tissue and remained as plasma cells. A few nerve fibers were seen in cross-section. The trabeculae of the bone showed well formed laminae.

The haversian canals were lined by active osteoblasts, and their lumina were filled with fairly dense connective tissue. The margins of some of the canals showed evidence of osteoclasis. The marrow spaces were practically all replaced

by a proliferation of connective tissue. The blood vessels were dilated, and their walls were thickened. Several of the marrow spaces showed notching, and in a few, waning resorption of the bone by osteoclasts was seen. The majority of the marrow spaces showed proliferation of active osteoblasts around their margins and apposition bone was being laid down. No reticular bone was being formed. Several perforating blood vessels had also grown into the trabeculae of the bone, but they had ceased to be active. The sections showed two small masses of cartilage in close apposition to each other; probably they were merely portions of one mass. One of these masses stained rather diffusely with eosin, and the margins tended to merge into the surrounding fibrous tissue. This portion was probably undergoing slow mucoid degenerative changes, but there was no marked activity of the contiguous fibrous tissue. The degenerative change in the small piece of cartilage was probably due to an acute inflammatory condition of the tissues forming the atresia.

THEORIES OF CAUSATION

Having traced the development of the nose and bearing in mind what was found at the examination and at the operation in the two cases of complete atresia of the choanae, I shall attempt to solve the problem of the genesis of this pathologic formation.

The present theories of causation obtaining on this subject are: (1) persistence of the nasobuccal membrane; (2) an overgrowth medialward of the vertical and horizontal processes of the palatal bone, and (3) results due to an inflammatory condition of the nasal passages in utero. A fourth theory can now be added, namely, persistence of the buccopharyngeal membrane. The third of these theories is brought forward in almost every pathologic congenital condition. None of the observations agrees with such a theory, and it is useless to give it any further consideration.

Persistence of the Nasobuccal Membrane.—This is probably the most popular theory of the causation of congenital choanal atresia. The most assailable point in this argument is the type of bone found when the occlusion is of the osseous or membrano-osseous type. It was said that the nasobuccal membrane was formed by an ectodermal invagination into the mesodermic substance of the embryonic skull. The mesoderm disappears before the inroads of the ectoderm till finally a thin layer remains which separates the primitive nasal cavity from the primitive mouth. Should bone be formed in this nasobuccal membrane it would be of the membranous type, i. e., bone formed from membrane. Unfortunately for this theory, the bone has been shown to be formed from cartilage. Nevertheless, the main theory cannot be dropped just because a portion of it is found not to coincide.

When the occlusion is of membrane, the only theory that is tenable must originate from a persistent nasobuccal membrane.

Overgrowth Medialward of the Vertical and Horizontal Palatal Processes.—This would seem to bridge the gap that was found in the theory of the nasobuccal membrane. These palatal processes are of bone formed from cartilage, and it seems likely that the bone found in a congenital choanal atresia must originate from this source.

In such a condition the bone tends to become tolerably thin as it spreads medialward, but where it is contiguous to the horizontal and vertical palatal process it is thick and very dense.

It must therefore be concluded that in cases of congenital choanal atresia in which there is a bony foundation there are two factors at work, namely, a persistent nasobuccal membrane and an overgrowth medialward of the horizontal and vertical palatal processes.

Persistence of the Buccopharyngeal Membrane.—From the observations in case 1 of the bilateral congenital choanal atresic group, there can be no doubt that the greatest degree of atresia is formed, in part, by the buccopharyngeal membrane. If the nasobuccal membrane can persist, why cannot a remnant of the buccopharyngeal membrane exist that is morphologically similar? The probable reason why so few cases of this nature have been encountered may be due to the difficulty in keeping the infant alive beyond the first day or two.

I have thus endeavored to make clear that all of these theories and their processes are interdependent.

SUMMARY

1. There are three degrees of congenital choanal atresia, which are due, respectively, to: (*a*) persistence of the buccopharyngeal membrane, excessive growth medialiy of the horizontal and lateral processes of the palate bone and persistence of the nasobuccal membrane; (*b*) excessive growth medially of the horizontal and lateral processes of the palatal bone and persistence of the nasobuccal membrane, and (*c*) persistence of the nasobuccal membrane.

2. The obstruction may be bilateral, or more commonly unilateral, and is absolute.

3. As age advances and when the obstruction is of bone, it tends to become more dense owing to the sclerosis secondary to the inflammatory condition in the obstructed nostril or nostrils.

4. The condition of bilateral choanal atresia occurred probably in three members of the same family and has not been proved to be handed down from parent to child.

5. The sense of smell depends on the extent of atrophy of the olfactory nerve endings. In cases of bilateral atresia the sense of smell was perceived a few days after operation.

6. The normal mucus stagnates in the affected nasal cavity or cavities and in time creates a pathologic condition of the lining membrane of the nose and also hypertrophy of the adjacent conchae.

7. Treatment is essentially operative. After removal of the atresia, the posterior third of the nasal septum should be resected in order to prevent any cicatricial contraction of the newly formed choanae. The after-treatment consists in frequent nasal and nasopharyngeal irrigations at fairly high pressures and the application of an oily spray to these regions.

CORRECTION OF NASAL DISFIGUREMENTS BY READJUSTMENT OF THE FRAMEWORK AND TISSUES *

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When one speaks of the nose in its relation to reparative surgery, the implication is not quite the same as when one sounds the familiar "eye, ear, nose and throat." In the main, in reparative surgery, one is concerned with the visible organ and its component elements as far as the general level of the face. This is not to say that the sinuses and deeper structures are out of the picture; they are always present in the mind of the operating surgeon. It simply means that in most cases actually presented the problem is confined to the visible organ, a part of the general subject which, curiously enough, has not been given the benefit of such intensive study as has been accorded to the areas not directly visible. There are, of course, good reasons for this difference. Until recently, it has been the predominant view of the medical profession that the outer organ is a menace to the general well-being by reason of its liability to injury, which results in occlusion of the airways, and, following the same thought, that attention to the septum frequently suffices to remedy this disturbance of function. There are those, one learns, who look with professional disfavor on any interference looking to readjustment that goes beyond this fundamental requirement.

In reparative surgery, there is a departure from this view. And once that departure has been made, it is perceived that the outer nose has attributes of its own that must be studied and allowed for if justice is to be done to him whose countenance it may disfigure.

At the root of the matter, of course, is admission of the right of the human being to look human. It may be possible to clear the airways and still leave the victim of an accident with his nose distorted, but if that distortion can be eliminated there is no valid reason for condemning the victim of the accident to go through life lamenting his own imperfection and drawing on himself the commiseration of his fellows, which all too easily passes into avoidance, the fruitful occasion of further misery. The hard fact is that those most concerned do not lightly or willingly accept the situation as one that has been visited on them by inexorable fate, and from which there is no escape. It is enough for

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them to know that there is no need for them to be marked for life. Once they have attained that knowledge, they seek the relief to which they believe themselves entitled. The present point is that if there is a thorough understanding of the nature and the behavior of the elements which compose the outer nose, those with a defective nose may be assured of obtaining relief that is adequate and satisfactory. It is true that if this preliminary knowledge on the part of the surgeon is absent, the attempt at restoration is destined to fall short of what it might be. There is no better illustration of the proverb that what can be done well can be done easily.

DIAGNOSIS

In the cases under consideration, in which all the constituent elements of the nose are present, it is evident that the disfigurement observable is accounted for by the fact that some or all of these elements are out of their normal positions. Diagnosis, therefore, must be in terms of the normal and of divergence from the normal. Equally, correction consists in restoration of the normal relations, not merely of some of the parts, but of all of them.

The variety of disfigurements is almost infinite, but whatever the appearance may be it is traceable to the nasal bones, the septum, the two sets of lateral cartilages and the columella. Any of these elements or all of them may be out of the normal position; the operator must be clear as to whether one, more than one or all of them are affected. Without that knowledge, he cannot possibly form a mental picture of what the nose will be when the correction has been made, and unless his mind carries such a picture he cannot well produce its ultimate counterpart.

THE NASAL BONES

The elements must be studied one by one, and since the nasal arch inevitably invites inspection, consideration of deformity may well begin there. From the point of view of what ought to be, the nasal arch consists of two small bones united to each other along the median line of the arch, and each united to the frontal bone above and to the maxilla laterally. It is pertinent to the diagnosis that these unions are effected by indenture processes (sutures), which constitute lines of weakness when the bones are under pressure. Were it otherwise, and were the bone of the arch integrally continuous with the maxillae and the frontal bone, it would be crushed and fractured by a heavy blow. As things are, there is a yielding on the lines of indenture, the two members of the arch finding new positions without, in most instances, being shattered. According to the direction of the blow, the separation may be on the line between the nasal bones themselves, producing a spread of the dorsum in that part; or there may be dislocation from the maxilla

on one side with crowding over of the bones to the other side. It does happen that the crushing effect of a blow of great violence will carry deeply enough to damage the perpendicular plate of the ethmoid, and, although this is unusual, the possibility must not be ignored. When one has become accustomed, through experience, to the observation of disfigurement in the upper part of the nose, one gets to know what manner of disturbance followed the blow, if there was one, and what changes in form have resulted from subsequent delays. It should be added that malformation in the nasal arch may be congenital, or may have had other origin, but in either case study of its actual aspects is the same as if the disfigurement had been produced by trauma.

THE SEPTUM

The nasal septum is involved in almost every disfigurement. Being a flexible body, it yields easily to every pressure. It forms the line of division between the two airways and serves as the support of that portion of the dorsum which is inferior to the bony arch. It has attachments to the nasal bones, to the perpendicular plate of the ethmoid, to the vomer and the vomerine cartilage, to the spine of the maxillae, from any or even all of which it may be dislocated. The upper lateral cartilages go off from it, and that connection may be broken. It supports the columella, invests the tip of the nose and sustains the lower cartilages of the alae. If it is dislodged or bent or for any reason fails to exercise its function of support, it reacts on the other parts and produces distortion and is the principal agent in producing occlusion of the airways. Even when there has been no injury, protrusion of the nasal septum or, contrariwise, its inadequate length, may produce a condition that is a real disfigurement. There can be no adequate correction of nasal disfigurement unless and until the septum has been straightened and its function of support has been restored. Plainly, therefore, in any diagnosis of the disfigurement it is essential to ascertain just what has happened to the septum, and all plans for correction must be dependent for success on the ability to eliminate its deflections and inadequacy.

A concrete and interesting example is to be found in those cases in which disfigurement is the sequel to resection of the septum in ordinary "nose and throat" practice; these cases are surprisingly frequent. In some instances not sufficient thought has been given to the septum's function of support, with the result that the buttress left after resection is insufficient for the purpose. In others there may be a history of infection, with resultant separation at the places of contact between the septum and the bones, whether those of the nasal arch, the perpendicular plate or those on the floor of the nose. Hence there are, depending

on the location and number of such dislocations, certain characteristic disfigurements. These include a simulated hump at the inferior end of the bony arch, more or less marked depression over the cartilaginous bridge, the nose tip fallen and probably bent to one side, the columella bent and retracted and, within the nose, fresh blockage of the airways.

It should be mentioned in passing that in respect to the septum the same rules apply to young children as to adults. It used to be held, with fairly general acceptance, that in dealing with the septum in children one should await the development of the vomer. Now it is seen that unless the distortion of the septum is corrected, the vomer is inhibited from developing normally, so that at the end it may be contributory to distortion.

Fig. 1.—This and the following illustrations show the subject before and after operation. The condition before operation was: depression over the cartilaginous bridge; hypertrophied alae; tip retrousse; widening of the bony arch, and exaggeration of the nasolabial folds.

THE COLUMELLA

By reason of its attachment to the septum, the columella inevitably follows the fortunes of that body. When, for example, the septum has been dislocated from the spine of the maxillae, and perhaps farther back along the floor of the nose, the columella is drawn back within the nose. If through any other failure of the septum the tip of the nose droops, the columella sinks on itself and bends, necessarily reducing, by its wrongly placed bulk, the access to the nostril. In fact, too little attention has been given to the columella in relation to the nostril. Looking on the columella merely as the covering of the anterior edge of the septum, one loses sight of the fact, which is nevertheless obvious

enough, from its close relation to the mesial crus of the alar cartilages, that it forms one side of the nostril, and that if the columella is too wide it tends to diminish the opening. In extreme instances this may approach a limitation on breathing like that found in the condition of atresia. Correction of the condition is clearly indicated, even if it were not, as it is, a disfigurement.

THE ALAR CARTILAGES

The upper lateral cartilages are thin plates spreading outward and downward from the superior rim of the septum. Enclosed within softer tissues, they are important elements of the framework, contributing as they do to giving and maintaining the normal shape of the nose in the area in which they are placed. Under trauma, they may be dislocated from the septum, or one of them may be bent on itself. After a delay,

Fig. 2.—Marked deflection of the septum to the left; distortion and misplacement of the columella; partial collapse of the alae; the nose below the bony arch deflected to the left, with marked depression over the right lateral cartilages, bulbous on the left; partial occlusion of the right nostril, and total occlusion of the left.

it may be found that one has thinned unduly and the other has become hypertrophied. Correction of the disfigurement resulting from hypertrophy demands that some excision be made. Equally, if the cartilage has been bent, it must be straightened. There must be a correspondence between the two sides if the nose after repair is to be symmetrical in the part where these cartilages give form to the tissues overlying them. Diagnosis will therefore include careful examination to determine what, if any, alteration has been produced either in the substance of the cartilages or in their relation to other parts of the nose.

The lower lateral cartilages call for even more careful inspection. It is not only at the arch and along the septal part of the dorsum that there may be disfigurement. The alae and the tip of the nose are, in

fact, not merely liable to be distorted where there has been any considerable violence, but when so affected present problems requiring the nicest order of readjustment. The shape, and also the function, of the nostril is influenced by one part of the cartilage, which extends over the outer alar wall. The other extension, passing down alongside the septum, with its counterpart establishes the cleft at the tip of the nose. If there is separation at that point, the contact and alinement must be restored. If the cartilage on one side has been thinned and that on the other side thickened, there must be some paring to make ultimate symmetry possible. Obviously, if these cartilages are not restored to their proper situations and brought to symmetrical proportions, disfigurement will remain no matter how much attention is given to the septum and the bony arch.

In the correction of nasal deformities in which all the elements are present, a further importance attaches to these lateral cartilages, especially the lower. It frequently happens that when the best has been made of the septum in its relation to the line of the dorsum, a small depression remains. It even happens that such a depression may be the whole disfigurement. Should there be a thickening of one of the alar cartilages, the morsels excised to effect the local correction can be utilized to fill such a depression. If one such morsel is not sufficient for the purpose, two or three of them may be laid one on the other and held with a suture. Even if there should be no need for reducing the cartilages for the sake of correction in the immediate area, small amounts such as will be required to fill the small depression on the cartilaginous bridge can be spared provided conservation at the rim is assured.

Alar cartilage used in this way has the advantage of being received by the tissues without protest; it does not disintegrate or otherwise lose its consistency. In this respect it is much to be preferred to cartilage from the ear, which tends to disintegrate when placed in the nose, or to cartilage from the septum, which does not thrive when detached from the main body, although when moved on a pedicle (as to lengthen the nose) its nature is not adversely affected. The availability of these morsels of alar cartilage to fill small depressions is in some respects the key to these operations for correction of nasal disfigurements in which all the elements are present and some of them displaced. It obviates the necessity of more serious surgical measures such as must be resorted to when, to give support to the tissues of the nose, cartilage must be brought from another part, e. g., the costal crest. There is here, therefore, a clear indication of the double necessity for precise recognition of what is the actual state of these alar cartilages when making the diagnosis.

THE NOSE AND THE FACE

Having, by such an inspection as has been outlined, determined how far the different departures from the normal contribute to the existing disfigurement, one must next think of what form the nose is to take when correction has been made. Briefly, it must fit the face. There is no point in trying to construct a Greek or a Roman nose in a face to which it does not belong. In the United States one gets to realize, in a hospital perhaps better than elsewhere, that the population is cosmopolitan. Heads and faces are of infinite variety of forms, and a nose that is normal on one face would be totally out of place on another. What constitutes disfigurement is the fact that the eye at once recognizes the abnormal. What constitutes correction is such change as

Fig. 3.—Septum markedly S-shaped and deflected, with occlusion on both sides; wide bony arch, twisted to the left; depression over the cartilaginous bridge; hypertrophy of the lower lateral cartilages; distortion of the tip of the nose and columella, and a moderate degree of hanging septum.

will leave no occasion for a second and critical look. It is with these considerations in mind that one makes his plan for the reconstruction, which will follow the resetting of the elements in their normal relations.

OPERATIVE TECHNIC

Anesthesia.—Practically all of these operations are done under local anesthesia. Apart from its other advantages, it has that of leaving both sides of the whole face under view all the time, a matter of no small importance when symmetry counts for so much. When general anesthesia is necessary, intratracheal insufflation of ether is the method of choice.

Modes of Access.—The preferable method of access to the tissues within the nose is by means of a pyriform incision, just within the nostril and following its curve. In many instances this will provide entry to the septum, to the lateral cartilages and to the bones of the nasal arch. The problem presented by the

septum may, however, make it desirable to adopt another method. In that case the method of choice is to expose the cartilage by means of an incision posterior to the columella, on the whole length of its association with the septum. The columella may then be retracted to one side strongly enough to enable the operator to deal effectively with the distorted septum. In instances that cannot be excluded from speculation, there may be advantage in approaching the septum through an incision piercing the columella from the surface on its vertical length; or the incision separating it from the septum within the nose may be carried to the surface at the philtrum, permitting the columella to be raised and held out of the field.

Reconstruction Begins with the Septum.—It is obvious that before anything else can be set right in the nose, the cartilaginous septum, the location of which will determine the form, must be given the place it is to have when the plan of reconstruction has been realized. However much it may have been distorted, bent, shifted or weakened, the first necessity is to arrange that it will give support to the tissues and establish the line of the bridge that is to be. To straighten it, to strengthen it, to eliminate the occlusions it may have been causing, to adjust its contacts where there has been dislocation, may make serious demands on surgical skill, but those demands, whatever they may be, must be met if the correction contemplated is to be effective.

Rectification of the Lateral Cartilages.—Usually when the septum has received the necessary attention, it will be convenient, proceeding from the pyriform incisions within the nostrils on both sides, to eliminate the abnormal conditions that may be perceptible in the lateral cartilages. This consists, especially perhaps as far as the lower laterals are concerned, in reducing the one that has been hypertrophied to the same size as the one on the opposite side, and then in restoring the relation of the descending section to the septum at the tip of the nose. It may very well be that to accomplish this the alar cartilages must be completely freed from the tissues in which they are embedded. Generally some reduction is necessary in one or in both. The morsels removed are carefully hoarded for use at a later stage. Similar excisions from the upper lateral cartilages may also be necessary, as well as other measures if there has been a breach of the continuity with the septum. Not infrequently it is to be noted that the cartilages are so thin as to be inadequate to support the wall of the nostril during inspiration. The inflow of air becomes difficult. In time, the curve of the cartilage comes to be concave instead of convex. In that case it is practicable to reverse the surfaces, thus restoring the convexity; or, if the cartilage is too thin, improvement may be made, following diagonal incisions within the nose, by changing the direction of the cartilage from the vertical to the horizontal relation, the outward curvature being influenced by the method of closing the incisions within the nose.

Approach to the Nasal Arch.—From the same pyriform incisions, the bones of the nasal arch are now to be approached. But since in dealing with them it will be necessary to separate the periosteum, carrying outward with it the tissues by which it is overlaid, and since these tissues are also, on their other side, in close relation with the skin, it is desirable to separate the skin from the tissues that underly it, in the interest of subsequent freedom of movement, as applied to these tissues, which would be inhibited by the skin attachment. This is done by free undermining well outward beyond the line of junction between the nasal bones and the maxilla on each side. In this stage great respect must be shown for the vessels. With blunt end scissors, the separation can be achieved with a minimum of bleeding.

Restoration of the Nasal Arch.—With a knife protected on the back, incision is made through the muscles overlying the median line of the periosteum and the periosteum itself, centrally and on both sides, and from these incisions the periosteum is separated and retracted, the retraction including the overlying tissues.

The way is now clear for dealing with the bones. Obviously, if there has been severe trauma, the line of junction between the nasal bones will have been shifted to one side. Palpation, however, will disclose the new location. Identification is important, as this line will form the apex of the arch when the bones are reset.

There follows the elimination of any irregularities that there may be on the bone surfaces (spurs). This is done with a chisel, the force being applied by a mallet. There is debate as to the choice of this instrument, some years ago vogue having been given to the use of the saw. But there is no room for doubt as to which is the better. With the chisel the application of force is in the direct line of the mallet's impact; with the saw there is no such certainty. With the chisel

Fig. 4.—Septum bowed to the right, producing obstruction in the right nostril and leaving the left nostril twice its normal capacity; the bony and cartilaginous bridge markedly elevated; hanging septum; drooping nose tip, and columella distorted to the right.

the cut is clean; there is no difficulty in finding and immediately removing the particle excised, whereas with the saw particles of bone dust so small as to be beyond possibility of identification and removal remain where they fell, their osteogenic properties unimpaired, and in a medium favorable to their growth and expansion. Thus the way is paved for new disfigurement. This statement might conceivably be challenged as merely theoretical, but the same cannot be said of actual cases in which such excrescences have had to be removed.

When the thickened bone has been reduced to desirable proportions, it still has to be brought to place as one side of the arch. This is manifestly impossible unless the bones are detached from their association with the maxillae. Here again a clean cut is made with the chisel. In the interest of subsequent drainage this incision is carried through to the interior of the nose. It should be mentioned that some variation in the size of these chisels is occasioned by difference in what is demanded of them.

Thus disengaged, the bones are raised to the degree necessary to establish the line of the arch. They do not rest on the maxillae at the inferior edge, but are, as a rule, lifted a trifling distance above the maxillary borders. The process of reorganization begins almost immediately, any interval between the freshly chiseled bone surfaces being filled in an incredibly short time. As regards their relation to each other, thumb pressure on the liberated nasal bones is relied on and ordinarily sufficient. At this stage it is important that the assistant maintain a pressure at the root of the nose, first to insure the retention of the arch in the place and at the height assigned to it, with special concern for the new line of the bridge resulting from alinement with the septum; and second, to interpose a check against bleeding, as a precaution against subsequent infection. Either now or a little later, small rubber drains are introduced. These pass from high up in the arch, through the nostrils (which, if the septum has been resected, are packed with gauze) and out at the border of the nostril farthest from the septum.

Adjustment of the Columella.—Rectification of the columella may have been accomplished by the attention given to the septum, but not invariably. The readjustment of the septum may have made it necessary, in view of the nature of its distortions, to disengage the columella from it. If so, the contact must be renewed. Frequently, correction of the distortion at the tip of the nose necessitates employment of the "orthopedic stitch" in reuniting the columella to the septum. If the circumstances call for some lifting of the columella to take strain off the tip, the suture threads are placed a little higher in the septum than in the columella; when drawn tight, the columella is raised to the level of the septum stitch. The proceeding is reversed when the object is to depress a little the tip of the nose that has been crowded upward or backward.

Final Definition of the Dorsum.—It is conceivable that when all parts of the nasal framework have been reassembled as described, the line of the bridge will be regular from the frontal bone to the tip of the nose. But it is almost inevitable that there has been some loss of substance of the septum, some slight inadequacy in the area where the septum meets the nasal arch and hence some slight depression of the cartilaginous bridge. To fill that depression, the morsels saved from the trimming of the lateral cartilages are brought into use. If one is not sufficient, two or more may be superposed to attain the density needed, these being held together by a suture and shaped to suit the particular occasion.

Support by Bandage.—All that remains is to retain for forty-eight hours the form that has been given to the reconstructed nose. To this end there has been much experiment, but as yet nothing has been found to compare in suitability with cotton roll bandages carefully applied to both sides of the nose and properly immobilized. Under light pressure, the rolls fit closely at all contacts, and they adjust themselves readily as swelling recedes. Immobilization should be thorough. To secure it, a wide strip of adhesive bandage is made fast around the back of the head and over the ears (protected by absorbent cotton) to the malar area on each side. Strips of adhesive tape anchor the bandage rolls to this wide bandage at the surface level on the side of emplacement, and then by means of other adhesive strips, carried in the opposite direction and around the head, the roll on one side is made fast to the wide bandage on the other side. As even this does not fully meet the situation at the upper part of the nasal arch, another fairly wide strip is brought down over the forehead, and a packing of cotton or stent is placed under strips of adhesive tape, binding the rolls to this forehead bandage. After two days, the bandages are removed and are not renewed.

Rapidity of Reorganization.—By this time the bony arch has become firmly established, so rapid has been the process of reunion with the adjacent maxillae as well as the adaptation of the other parts in their new relations. It goes without saying that in replacing the periosteum no part of the nasal bones is left exposed, and that the tissues overlying the periosteum, and the skin covering, have been carefully molded in the interest of symmetrical form. Owing to the control of bleeding by the assistant and to the drainage, discoloration is reduced to the minimum. It is therefore possible for the patient to leave the hospital on the third day, rarely later than the fourth or fifth.

Simplicity and Rapidity of the Procedure.—Although the detailed description might give the impression of complexity, the fact is that once the diagnosis in terms of the normal and of distortion has been made and the form to be attained has been settled in the mind of the operator, the procedures are both simple and rapid. Except in unusual

Fig. 5.—Septum deflected; almost total occlusion of both nostrils; marked exaggeration, in width and length, of the bony arch; depression over the lower third of the cartilaginous bridge; upturning protrusion of the tip of the nose; columella twisted in a very unusual degree; hanging septum; superior spine of the maxillae, enlarged and misplaced, and resulting characteristic narrowing of the upper lip.

cases, a half hour may suffice, and, as has been shown, by the exercise of proper care the period of hospitalization is brought to an irreducible minimum. Similarly, the instruments used are of the simplest; a scalpel for the incisions, sharp, small scissors for cartilage adjustments, blunt scissors for separation, a knife with a single edge for incising the periosteum and a few chisels and a mallet for reducing and freeing the nasal bones. These, with the bandage, account for everything but the sutures.

SECONDARY HARELIP A NASAL DEFORMITY

That there is great variety in the forms of disfigurement which may be produced, in one way or another, without loss of the elements of the nasal framework, all are aware. There would be no purpose in attempt-

ing to classify them. There is one special condition, however, which here invites particular attention, since it falls within the scope of such reconstruction as has been discussed and yet presents some features peculiar to itself.

Secondary harelip in adults is to be recognized as, principally, and in regard to correction, primarily, one of nasal deformity. Making the diagnosis in the manner here outlined, with attention to the departure from the normal in each of the elements, one learns that certain characteristic consequences flow from the failure of development. The harelip itself is one of these consequences. But a comparison between the two sides of the face also reveals that the asymmetry is not localized but affects the whole of the area on one side as compared with the other. Naturally, the septum is shifted to the side of the cleft; also, the line of the spine of the maxillae, which the septum follows on the floor of the nose, is apt to be to one side of the median line. When in the process of correction the time comes to establish a new position for the septum, it may have to be dislocated from the spine and set somewhat to one side in order to get it in a central location. In that event, the chisel must be brought into use to remove the spine, which otherwise would constitute a pyramidal elevation within one of the nostrils. Even when the septum has been thus removed to a position on the floor of the nose which serves as a base line on the sides of which the other elements can be arranged so as to make the nose straight and symmetrical, one sees that the visible organ does not occupy the central position on the face.

Next, inspection reveals that such distortions are present as are to be looked for when the septum is deflected. There is a simulated hump at the lower end of the nasal bones; the columella is inevitably distorted, perhaps in more than one direction; the ala, on the side away from the cleft, has lost its form by yielding to the pull of the septum. On the side of maldevelopment, the alar condition is even worse. Here there is usually some degree of fixation of the tissues of the face to the bones beneath, the ala, held out of place by this condition, being long and thin. The procedure for reconstruction of such a nostril goes somewhat outside of what was discussed in the first part of this article,[1] but is essential if the characteristic form of the nose accompanying harelip is to be corrected.

Again, the mere reconstruction of the nostril does not end the matter, for the newly formed ala is still, in many instances, exposed to the influence of the inert muscles on that side of the face. It is therefore generally essential to eliminate such influence, and this can be effectively done after the adhesions before mentioned have been dealt with by

1. Sheehan, J. E.: Plastic Surgery of the Nose, New York, Paul B. Hoeber, 1925, pp. 125-127.

separation, with the aid of a Thiersch graft covering applied continuously in the manner of a pouch to the upper side of one and the under side of the other of the surfaces that had adhered. Without this, adhesion would be renewed, and the alar distortion with it. In time the nasal framework would yield, and new distortion of the elements would become apparent. The lining of the tissues, on the other hand, conduces to facial mobility and eliminates the strain.

When the nose has been reconstructed, the defect of the lip presents only minor difficulties, into which it is not necessary to go at this time. What is to be emphasized is that in these cases of secondary harelip in adults, even if the immediate attention is directed to the condition of the lip, it is the deformity of the nose that seizes attention qua deformity. With that deformity removed by correction, consciousness of what remains of the deformity of the lip is much less, and there is a much better prospect that that deformity will be removed.

CORRECTION

In Dr. Emil Amberg's discussion on the paper by Dr. H. J. Profant, entitled, "Gradenigo's Syndrome with a Consideration of 'Petrositis,'" which appears in the March issue (ARCH. OTOLARYNG. **13**:3, 1931), the eighth line from the bottom should read "I learned of two other cases" instead of "another case."

Clinical Notes

MUCOCELE OF FRONTAL SINUS

Its Occurrence in a Boy Aged Thirteen *

H. C. Rosenberger, M.D., and C. E. Kinney, M.D., Cleveland

In reviewing the subject of mucocele of the nasal accessory sinuses and of the frontal sinus in particular, one finds that the condition is less common than is usually thought. In 1921, Dabney [1] listed 74 cases in a rather exhaustive review. In 1923, St. Clair Thomson and M'Illraith [2] cited 100 cases, but apparently there was duplication in these articles.

There is a rather wide variance of opinion among writers as to the age incidence of mucocele. Garretson [3] stated that the disease is manifested in late middle life, while Dabney stated that it is a disease frequently seen in youth. In the case reported here the patient, 13 years old, was younger by several years than the patient in any case mentioned in the literature reviewed.

The symptoms fall into two groups: those in which the cyst encroaches on the orbital cavity, thus causing symptoms of the eye, and those in which the cyst obstructs the nasal cavity. Plandé [4] reported an interesting case in 1928, in which the patient had a cyst removed from the inner wall of the left orbital cavity at the age of 17 and nine years later was operated on again because of extreme headaches and symptoms of a tumor of the frontal lobe. At this time a large mucocele of the left frontal sinus was found, which had eroded through the posterior wall of the sinus.

The etiology is by no means established. The two most plausible explanations are: 1. It is due to enlargement of a minute retention cyst of one or more mucous glands often seen in a routine examination of lining membranes removed at operation. 2. It is due to closure of the nasofrontal duct from (*a*) trauma, (*b*) obstruction or (*c*) inflammation.

Why the condition is practically never seen in the other nasal sinuses is a question. Possibly the explanation lies in the fact that the condition is otherwise diagnosed when it involves the other sinuses. We make this statement because in the routine injections of iodized oil into the diseased antrums, such as we have been making for over a year, we have seen several cases in which the oil has been injected into an antral cyst which, when removed, had all of the pathologic appearances of a mucocele.

In the literature reviewed there was no mention of any case having been associated with malignancy. The treatment that is universally advocated is radical removal of the entire cyst by the Killian procedure or one of its modifications.

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* Submitted for publication, Nov. 18, 1930.

* From the Department of Otolaryngology, St. Luke's Hospital.

1. Dabney, V.: New York M. J. **114**:619, 1921.

2. Thomson, St. Clair; and M'Illraith, C. H.: J. Laryng. & Otol. **38**:365, 1923.

3. Garretson, W. T.: Laryngoscope **37**:350, 1927.

4. Plandé: Rev. de laryng. **49**:176, 1928.

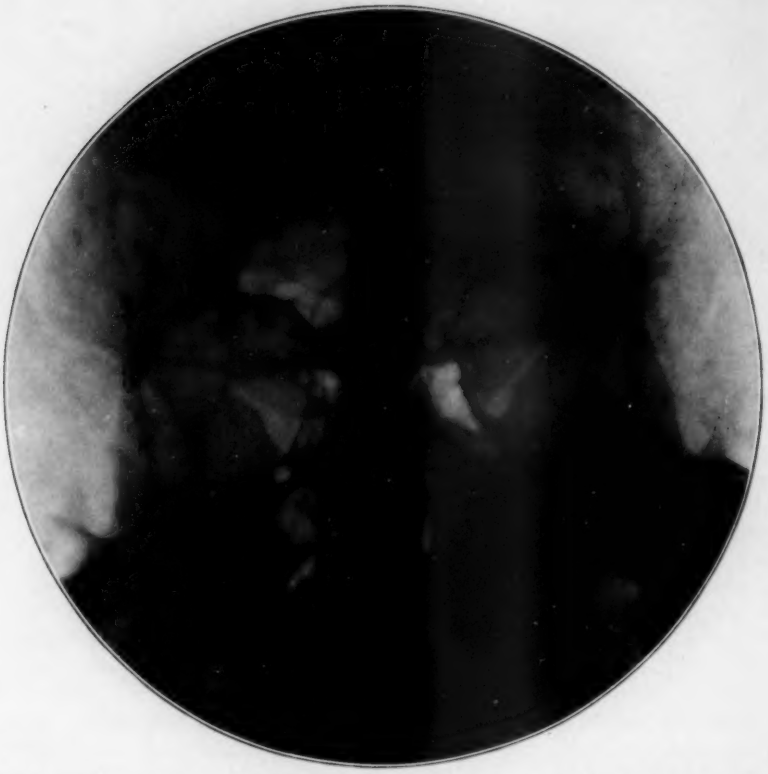

Fig. 1.—Roentgenogram showing the cloudy right frontal and right maxillary sinuses.

Fig. 2.—Appearance of patient after operation.

REPORT OF CASE

History.—S. V., a white boy, aged 13, was brought to our eye clinic on Sept. 5, 1930, because of a small tumor on the medial side of the right orbital cavity. The mother stated that this was first noticed ten months previously, and that it grew slowly for about three months. The tumor then remained stationary for two months, and again receded until two months before his admission, when it was barely noticeable. It then began to enlarge again until the time of admission to the hospital, when there was a fairly marked ptosis of the right upper eyelid with a slight exophthalmos, both of which were noted by the mother. There were no other symptoms. The past and family histories were negative.

Examination.—Physical examination gave negative results, except for the local condition. Laboratory work, including serologic examination of the blood, revealed nothing abnormal.

There was a round, rather tense, but slightly fluctuating tumor about 12 or 15 mm. in diameter, deeply embedded in the upper inner portion of the right orbital cavity. As far as could be determined, it was more closely associated with the floor of the right frontal sinus than with any other structure. There was a fair degree of ptosis of the right upper lid and slight exophthalmos, but no apparent lateral displacement of the eyeball. The eye itself was normal in all respects.

After cocainization, examination of the nose revealed nothing abnormal, except that the olfactory fissure on the right was wider than that on the left, owing to an extreme lateral position of the right middle turbinate.

Roentgen examination, as seen in figure 1, showed cloudy frontal and right maxillary sinuses on the right side. The maxillary sinus was irrigated and found to be clear. We interpreted this result as being evidence of an underdeveloped maxillary sinus on this side.

Operation.—On September 9, with the patient under general anesthesia, a radical operation was performed on the frontal sinus, according to the Lynch technic. When the sinus was opened, about 2 drachms of a milk-colored, syrupy liquid escaped. The membranes lining the sinus as well as the wall of the orbital projection of the mucocele were removed. No opening into the nose could be found, so that one was made corresponding to the site of the usual nasofrontal duct. This opening was enlarged by removal of the adjacent ethmoidal cells. A section of no. 16 male rubber catheter was passed through this opening into the nose, and the wound was closed without external drainage.

Course.—Except for the occurrence of serum in the wound requiring evacuation, the convalescence was uneventful.

Progress in Otolaryngology

A Summary of the Bibliographic Material Available in the Field of Otolaryngology

ANATOMY AND PHYSIOLOGY OF THE EAR

REVIEW OF THE LITERATURE FROM OCTOBER, 1929, TO OCTOBER, 1930*

PHILIP E. MELTZER, M.D.

BOSTON

ANATOMY

Kraus and Werkner,[1] after a detailed anatomic and roentgenologic investigation, expressed the opinion that the emissary vein is an inconstant vessel combining the deep and superficial veins of the skull.

It was found to be given off either into the sulcus on the posterior margin of the sinus or between that and the occipitomastoid suture, most frequently into the former (at the level of the middle sigmoid sinus). The number of the mastoid emissaries is variable; usually only one is found, but occasionally two are present. They were absent in 5 per cent of cases and unilateral in 7 per cent. In some cases a typical mastoid emissary was absent, while instead a peculiar bone defect was found which could be considered as an accessory emissary.

The thickness of the emissary veins varies between 0.5 and 6 mm. In general, there is no definite relation between the width or size of the sinus and thickness of the vein. The course in the bone itself is variable. The opening of the vein on the external surface of the skull is either anterior or inferior to the occipitomastoid suture, usually in the middle of the mastoid process. The flow of blood is toward the sinus, although in abnormal anatomicovascular relations it is possible that the entire amount of blood in the sinuses may flow out through the mastoid vein or that the latter may convey blood from the posterior fossae of the skull.

No direct relation could be shown between the lateral position of the sinus and the mastoid foramen.

The poorer the pneumatization, the smaller was the vein, up to complete absence; conversely, the greater the degree of pneumatization the better was the development in the size and width of the mastoid emissary vein.

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*Dr. Charles Gettes assisted in the bibliographic work and some of the reviews.

1. Kraus and Werkner: Ztschr. f. Hals-, Nasen- u. Ohrenh. **25**:270, 1930.

Schwartz,[2] after reviewing the various theories regarding pneumatization of the mastoid process and after having carried out numerous examinations in order to determine the significance of the hereditary anlage for the pneumatization of the mastoid process and the accessory nasal cavities, summarized his results as follows:

There is no doubt that heredity plays an important rôle in pneumatization of the middle ear space and the accessory nasal cavities. This statement is based on the fact that in roentgenologic studies of the mastoid processes of uniovular twins, the data obtained were more or less identical, while the observations were considerably different in the twins from two ova. This holds true for the accessory nasal cavities, although here the relations are less pronounced. Examinations were carried out on fifty-nine uniovular and thirty-five biovular pairs of twins, and three times in triplets. In one case of triplets two of the new-born were from a single ovum and the third from another ovum. Roentgenographic studies of the mastoid process revealed a more or less identical picture in thirty-nine or 66.1 per cent of the uniovular twins and in thirteen or 37.1 per cent of the biovular twins. Of interest is the fact that the best and the poorest pneumatized mastoid processes were obtained in the uniovular twins. This observation was interpreted as showing that a healthy mucosa is only slightly influenced by external conditions, while a mucosa that is constitutionally unable to pneumatize can no longer be unfavorably influenced by the external conditions. Differences in the pattern of pneumatization of the mastoid process were found most frequently in the average pneumatization. In these cases the mucosa apparently possesses an average structure and consequently is sensitive to external stimuli.

In cases of so-called "inhibited" pneumatization (the small cellular thick-walled form of slight extension) the pattern in the uniovular twins was often strikingly identical. While the extent of pneumatization in the uniovular twins was more or less the same in about 66.1 per cent, the structure of the mastoid processes frequently showed strikingly uniform pictures. In the biovular twins a similarity in structure was absent, as a rule. From these observations it is seen that external influences (the type of nutrition, general diseases, infantile otitis, etc.) play a rôle in the development of pneumatization. The degree of injury of the mucosa produced by the external influences depends to a great extent on the condition of the mucosa itself. The powers of pneumatization and protection are closely related or actually identical properties of the mucosa.

The relations are less pronounced in the case of pneumatization of the accessory nasal cavities. This is explained to a certain extent by the fact that the degree of development of the individual cavities is dif-

2. Schwartz, M.: Arch. f. Ohren-, Nasen- u. Kehlkopfh. **123**:161, 1929.

ferent at various times; as a result, the external influences that promote or inhibit pneumatization necessarily have a different effect on the accessory nasal cavities. A comparison of the individual nasal cavities resulted in the following values: In 50 per cent of the adult uniovular twins, the frontal sinuses were found to be developed to the same extent, while in the biovular twins this similarity was found in only 37.5 per cent of the cases. For the maxillary sinuses the following values were obtained: equal development in 68.2 per cent of identical twins and in 50 per cent of biovular twins; for the ethmoid sinuses, in 77.3 per cent of identical and in 50 per cent of biovular twins. It was impossible to obtain good results from roentgen examination of the sphenoid cells.

A study of the entire picture of the accessory cavities revealed development of the same degree in about 47.8 per cent of uniovular twins. Here a similarity was obtained in reference to size, form and position. In biovular twins the similarity is observed less frequently; it was found in only three of sixteen pairs of twins, i.e., in 18.6 per cent.

The relations are still more complicated when a comparison is made between the pneumatization of the mastoid process and the pneumatization of the accessory nasal cavities. In general, it may be stated that in some of the cases good pneumatization of the mastoid process was associated with good pneumatization of the accessory nasal cavities; this was true in 32.7 per cent of the uniovular and in 12.5 per cent of the biovular twins.

Albrecht [3] discussed pneumatization of the middle ear and made histologic investigations of the temporal bone in the new-born infant. He examined forty-four new-born infants, twenty-nine of which were full term and fifteen premature (from the sixth to the ninth month). The inspection of the specimens showed that individual differences were demonstrable in the process of pneumatization. He saw sections of premature infants in the eight month, in which the pneumatization was well advanced, whereas in full-term children a deficient pneumatization was observed. The pneumatization of the epitympanic recess shows especially large fluctuations. In a comparison of the two sides of the same person the investigations showed that an essentially exact uniformity between the right and left side was present in thirty-nine of the forty-four infants examined. In the five other cases the difference was only in degree, the pneumatization being the same or similar. It is noteworthy that in these cases, no relation of any kind could be demonstrated between the modality of pneumatization and eventual inflammation of the middle ear. The author's sections showed that there are demonstrable in intra-uterine life great differences in the mode and activity of the pneumatization which are not dependent on external influences, but which are idiotypical. The activity of the epithelium

3. Albrecht, W.: Acta oto-laryng. **14**:221, 1930.

shows great individual differences in the various cases. A remarkable conformity in pneumatization of the epithelium is recognizable between the right and left sides of the same person. Besides the different degree of energy of the epithelium, the variation in the resistance of the embryonic tissue is of importance in this connection.

Buscher [4] denied the existence of penetrating defects in the region of the pars flaccida. Various authors have described congenital defects in this region, but this author expressed the belief that they are probably degenerative changes preceding disturbances during the developmental period. They are, in reality, fine atrophies and clinically a great rarity.

Rasmussen,[5] in a study of the secondary vestibular tracts in cats following the production of small degenerative mechanical lesions in the vestibular nuclei, stated: 1. The superior vestibular nucleus sends fibers up the median longitudinal fasciculus of the same side. 2. The lateral vestibular nucleus sends fibers down the ventral fasciculus of the spinal cord of the same side. 3. The medial (triangular) vestibular nucleus sends fibers both up and down in the opposite median longitudinal fasciculus. 4. The descending vestibular nucleus, essentially a continuation of the medial nucleus, sends fibers down the median longitudinal fasciculus of the same side (this idea has been opposed). Rasmussen bases this conclusion on the small dorsal lesions that occur strictly within the vestibular nucleus just below the stria medullaris acousticus with no involvement of the reticulo-formatio. 5. Fibers from the nucleus fastigii are largely crossed, and some seem to continue with the fibers from the lateral vestibular nucleus farther down the spinal cord than is generally admitted. 6. Since most of the lesions observed were through the cerebellum, there is further evidence that the cortex of the vermis sends fibers mostly to the opposite nucleus fastigii.

HISTOLOGY, EMBRYOLOGY AND COMPARATIVE ANATOMY

Anson and Wilson [6] prepared models from serial section of the ear in a child, aged 2, showing that the utriculosaccular and endolymphatic ducts in man possess striking regional complexities. In the endolymphatic ducts specialization of the epithelial cells occur.

The lumen of the eliptical utriculosaccular duct is greatly flattened in its transverse plane; the portion of the endolymphatic duct that joins the saccule is similarly compressed, whereas at its point of communication with the utriculosaccular duct it is greatly dilated, becoming more so as it extends posteriorly. It then narrows at a point opposite the junction of the utricle with the crus communis of the semicircular canals. From there it turns superiorly and finally widens to join the endolymphatic sac.

4. Buscher, E.: Ztschr. f. Hals-, Nasen- u. Ohrenh. **25**:129 (Oct.) 1929.
5. Rasmussen, A. T.: Anat. Rec. **3**:227 (April) 1929.
6. Anson, B., and Wilson, J. G.: Anat. Rec. **3**:205 (April) 1930.

In the narrow portion of the duct and in the inferior portion of the sac, longitudinal ridges of epithelium enclosing a connective tissue core encroach on the lumen of the tube. These are somewhat vascular and there is some evidence that their epithelial cells possess basal processes.

Weber [7] discussed the occurrence of osteogenesis in an infant, 2 days of age. The endosteal capsule consisted of a thin layer of pathologically differentiated fibrillar bone. The endochondral capsule contained chiefly medullary substances. There were many fragments of cartilage surrounded by the deposits of altered fibrillar bone, which was variously noted as a transitional form between osteoid and chondroid tissue. Lamellar bone was not found, nor was there any evidence of osteoclasts. The periosteal capsule throughout consisted of the pathologically differentiated fibrillar bone which appeared consolidated toward the endochondral capsule, as there was no breaking down of tissue. The origin of the transformation lies in a generalized fetal inhibition of development leading to abnormal differentiation of the entire skeletal system with differentiation in the rest of the bony structures.

Streeter [8] reviewed the development of the ear. He stated that of the various sense organs the ear is the first to make its appearance. As the first somites begin to appear and before the closure of the neural tube, that part of the neural wall which is to furnish the acousticofacial ganglion exhibits an active proliferation of its cells, producing a lateral bulging from the lateral surface of this fold. The ganglion mass becomes detached by delamination. Coincidently, an area of thickened skin (ectoderm) becomes demarcated as the otic plate. The progressive differentiation of this otic plate and its invagination and detachment from the surface has been photographed and demonstrated in a series of twenty-four embryos, ranging from the stage of seven somites to embryos 4 mm. long, at which time the otic vesicle is completely established and the walls are histologically differentiated into parts that can be clearly recognized as the vestibular, cochlear and appendicular portions.

After the completion of the primary vesicle and its ganglion, changes begin to occur in the mesenchymal environment; at first a condensation of cells and soon a definite capsule of precartilaginous tissue. From the first, the capsule assumes definite relations to the membranous labyrinth, and one finds the endolymphatic appendage not enclosed. The latter is left naked to come into relation with the lateral sinus.

Along with the development of the precartilaginous tissue a reticular space, intervening between it and the epithelial labyrinth, makes its appearance. This reticulum can be traced into the eventual periotic

7. Weber, M.: Ztschr. f. Hals-, Nasen- u. Ohrenh. **25**:345 (Feb. 24) 1930; abstr., Arch. Otolaryng. **11**:669 (May) 1930.

8. Streeter, G. L.: Tr. Am. Otol. Soc. **19**:179, 1929.

spaces with their equipment of blood vessels. In the meantime the precartilaginous tissue becomes definite cartilage.

Versteegh [9] presented an anatomicophysiologic study of the labyrinth with only two vertical semicircular canals in *Petromyzon,* which belongs to *Cyclostoma,* a very low class of fishes. The two semicircular canals presumably correspond to the two vertical semicircular canals of higher vertebrates, while the longitudinal semicircular canal seems to be missing. The presence of ciliated epithelium points to a movement in the endolymph, in contrast with higher vertebrates, in which the endolymph is quiescent. *Petromyzon* (the lamprey) has only two vertical semicircular canals, while a horizontal semicircular canal is missing. The conclusion was reached that the semicircular canals of *Petromyzon* are to be considered anatomically as vertical. The interior of the semicircular canals is lined in part with ciliated epithelium, through which a portion of the endolymph is apparently kept in constant motion. This movement could be represented and demonstrated by the introduction of air bubbles and particles of animal charcoal. A film illustrating these phenomena was shown at the Third Scientific Meeting of the Collegium Oto-Rhino-Laryngologicum Amitiae Sacrum, in London, July 17 to 19, 1929. In the resulting discussion, Guild spoke of having described movement of the endolymph in guinea-pigs, in which ciliated epithelium is absent; the endolymph seemed to flow from its site of secretion in the stria vascularis toward the saccus, in which a special epithelium mediated the drainage. Similar conditions presumably prevail in man. Denker pointed out the desirability of ascertaining if *Petromyzon,* with its low-grade labyrinth, is capable of reacting to sound impressions, as was successfully demonstrated in other fishes, by K. von Frisch. Should a reaction to sound impressions disappear after the extirpation of the labyrinth, it would be necessary to assume that a portion of the vestibular apparatus is also capable of perceiving sound.

Burket [10] discussed in great detail the anatomy and physiology of the perilymphatic spaces and the behavior and relations of the perilymphatic duct in a number of vertebrates. He concluded with the following summary:

The sensory terminal organs in the labyrinth of the vertebrates may be subdivided into two groups. To the first group belong the three cristae ampullares, the macula utriculi, the macula laganae, the macula sacculi and the papilla neglecta. They react to movement or positional changes of the labyrinth. To the second group belong the papilla amphibiorum, the papilla basilaris (Corti's organ) and the maculi sacculi. The end-organs of the second group are also capable of reaction

9. Versteegh, C.: Nederl. tijdschr. v. geneesk. **73**:5921 (Dec. 14) 1929.
10. Burket: Nederl. tijdschr. v. geneesk. **73**:5921, (Dec. 14) 1929.

in standstill of the labyrinth. A part of the perilymphatic space is then transformed into a conduction system which leads from the capsular wall to the end-organ.

The sensory organs of the first group are not lacking in any labyrinth, but they are not always present at the same time. The sensory organs of the second group are found in some fishes, i. e., in the *Ostariophysi* and the *Clupeidae,* in all terrestrial animals and in their derivatives, such as *Cetacea,* etc. Correspondingly in all these forms a differentiation of the perilymphatic space occurs which makes possible the function of the corresponding sensory organs. This differentiation consists in the formation of a canal filled with fluid, which originates as the result of a local disappearance of the connective tissue trabeculae. In some amphibia there are one or two sensory terminals which are supplied by the perilymphatic duct. In *Sauropsida* and in mammals only one sensory organ is present. In reptiles this structure is variable; it is well differentiated and developed in crocodiles. The development of the end-portion is parallel to the formation of the perilymphatic system, which in mammals surrounds the entire pars inferior of the labyrinth. In mammals and birds it is definitely known that the perilymph conducts the sound waves to the corresponding end-organ, the waves being taken up by the latter. It is reasonable to assume that this is true also in the remaining vertebrates. It has been demonstrated in some types of fish and in reptiles. This proof is lacking for the amphibia, with the exception of frogs, and it is questionable whether the papilla amphibiorum is suitable for the reception of sound waves. It is difficult to determine how much the sacculus participates in the reception of sound waves. The relations between the sacculus and cisterna perilymphatica are more or less the same in all vertebrates, except for a few reptiles. The structure of the macula and its covering does not seem to indicate that this sensory terminal may have an entirely different function from the similarly constructed macula utriculi. A number of the functions of the end-organs of the labyrinth still remain unclear; it is important, however, to remember that the relations of the perilymphatic conduction system may enable one to judge the type and origin of the adequate stimulus to which it is adjusted.

Jung [11] made a number of experiments on the larvae of *Rana fusca, Hyla arborea* and *Rana esculenta,* to study the relation between the middle ear and the labyrinth. Of especial interest were: the behavior of the auditory nerve following the unilateral removal of the labyrinth, and the problem of the origin of the cartilaginous labyrinthine capsule and the regenerative capacity of the auditory bulb.

Puncture of the membrane of the labyrinth in *Rana fusca* did not inhibit its future development. Transplantation of the auditory bulb

11. Jung, G.: Ztschr. f. Hals-, Nasen- u. Ohrenh. **25**:527 (March 25) 1930; abstr., Arch. Otolaryng. **11**:669 (May) 1930.

into the orbit in *Rana fusca* in any stage of metamorphosis resulted in the formation of a cartilaginous capsule even if the membranous labyrinth was further developed. With unilateral removal of the labyrinth in *Rana fusca* and *Hyla arborea,* the inner ear did not regenerate, nor did the formation of the cartilaginous capsule, the operculum or the pars interna plectri occur. However, symptoms of vestibular deficiency were observed at an early stage, as was shown by the fact that the tadpoles swam in circles around the longitudinal axis in the direction of the side on which the operation was performed. The eye gradually moved caudalward, corresponding to the lowered resistance of the tissue. The cartilage of the middle ear, the pars media et externa plectri and also the annulus tympanicus were not inhibited in their development. In all these experiments with the unilateral removal of the labyrinth the stage of larval development was immaterial. Soon after the simple removal of the branchia with the underlying mesenchyma, complete regeneration occurred. The development of the middle ear was in no way influenced by this operation. Thus one infers that the mesenchyma of this region is differentiated at a later stage into cartilage. Likewise the internal ear was not touched by the removal of the branchia. When the auditory bulb was removed, however, together with the branchia on one side there was no new formation of a labyrinth, although the development of the middle ear was normal. These experimental results conform to conditions observed in the human ear: A normal middle ear and external ear are noted with a deformed or absent labyrinth and vice versa.

PHYSIOLOGY OF THE COCHLEA

Noltenius [12] described the course of sound waves as follows: The air vibrations strike the tympanic membrane and cause it to vibrate, supported by the "hearing tube-like" action of the auditory meatus, which prevents an escape of the sound waves to the outside. The excursions of the tympanic membrane are transmitted directly, namely, in the same unit of time, through the lever of the chain of auditory ossicles to the oval window membrane, causing this to vibrate synchronously. However, these vibrations differ from those of the tympanic membrane through a lesser amplitude, and proportionately possess an increased strength, capable of causing the more sluggish medium of the internal ear to vibrate. The author surmised a corresponding relation between the size of the lever arms and the magnitude of the two membranes on the one hand, and the density relation of the air and water systems on the other. This transmission is simpler in some animals than in man, for example in the frog, in which merely an eccentrically implanted rod connects the tympanic membrane and the window membrane. In the

12. Noltenius, F.: Arch. f. Ohrenh. **125**:234, 1930

second place, the sound waves are transmitted to the membrane of the round window by means of the tympanum. The action of the closed-off tympanic space is based on the fact that the sound vibrations coming from the tympanic membrane are unable to spread unhindered in all directions. Since the air particles can escape only through the membrane of the round window, the greater part of the sound energy of the tympanic membrane becomes concentrated in the round window membrane. Owing to its size, however, it must vibrate with a shorter amplitude and therefore a greater strength than the tympanic membrane. In the normal ear, the sound passes through the oval window into the scala vestibuli, and through the round window into the scala tympani, but with a significant difference: Owing to a rigid connection, the oval window membrane vibrates synchronously with the tympanic membrane, whereas the sound vibrations arrive a fraction of a second later at the round window membrane, as they must first pass through the air space of the tympanic cavity. Since sound is propagated more than four times as rapidly in the water system as in the air, the waves derived from the oval window presumably have reached the helicotrema when they arrive at the round window membrane. Through the scala tympani now pass two perfectly equivalent waves, but in an opposite direction; thus they must collide somewhere in the domain of the scala tympani. Here the entirely uniform but opposed waves become accurately superadded; pressure originates on the addition of two wave crests and the mass particles endeavor to escape and push against the basilar membrane, as this alone is a movable boundary layer. Thus a transversely directed vibration develops in the middle domain of the scala tympani, exactly corresponding to the vibration of the tympanic membrane and directing its beat against the basilar membrane. This is caused to vibrate transversely as a whole, as the vibrations pass from the point of stimulation toward both sides to the poles of the membrane; as the basilar membrane possesses only slight elasticity, the sound waves are greatly muffled if not entirely extinguished. Thus the vibrations of the tympanic membrane are minutely transmitted to the basilar membrane, without this membrane becoming the source of reflexes and interferences through vibrations of its own. The preceding is the first act of the auditory process, while the second act concerns the perception, namely, the differentiated perception of the sound. The basilar membrane with its apposed Corti's organ vibrates in the same sense as the tympanic membrane, and every sound vibration regularly stimulates all auditory cells, the intensity of perception being necessarily related to the amplitude of the vibration.

Perekalin [13] studied acoustic orientation by the production of definite sounds in definite directions. The experiments were carried out in a specially prepared space, 3.65 meters in width, 4.15 meters in

13. Perekalin, W. E.: Ztschr. f. Hals-, Nasen- u. Ohrenh. **25**:442, 1929.

length and 4.7 meters in height. For the source of sound he used: (1) a large whistle of the tone series of Bezold-Edelmann (1,152 oscillations per second), (2) a whistle giving 85.3 oscillations per second and (3) ordinary sounds of speech of various duration and intensity.

The following conclusions were drawn: 1. The localization of sound in a definite space is a function of binaural hearing. 2. The ability to localize sound is a property that is subject to great individual variations. The percentage of failures, under similar experimental conditions, in the same experimental subject, varies from 12.7 per cent (23 mistakes per 180 tests) to 53.8 per cent (93 mistakes in 180 tests). 3. The least number of mistakes is made in the horizontal plane, somewhat more mistakes, in the frontal plane and the most mistakes in the sagittal plane. 4. A computation of the correlation coefficient shows that the increase in number of mistakes in a definite plane is associated with an increase in the number of mistakes in the two other planes. 5. Of the various sounds studied, the interrupted, intense, high sound was found to produce the smallest percentage of mistakes, while the greatest percentage was produced by the drawn-out, high, weak sounds. The intense high sound was followed by the interrupted low sounds. 6. The number of mistakes was determined from the various directions of the circumscribed space used, such as, "straight from the left," "straight from the right," "straight from posteriorly" and "straight from anteriorly." 7. The movements of the head (the inclination of the ear toward the source of sound) and pinna participate in the localization of sound. The movements of the head are of great importance; they may exclude nearly all mistakes. The pinnae help in the localization of the sound on the right and left; they aid in differentiating an "anteroposterior" from a "supero-inferior" direction. They also aid in the localization of sound in the sagittal plane. 8. The exclusion of one ear leads to a disorientation, whereby the degree of the decrease in auditory power plays a considerable rôle. 9. These results favor the theory of time and intensity.

Zurmuhl,[14] in experiments at the Physical Institute of the University of Marburg, made a quantitative investigation of the phenomenon that a stronger tone sounds deeper than a weaker tone. He used modern measures, such as vibratory circles, special loud-speakers attuned to deep frequencies, noise-measuring instruments and tube voltmeters for the determination of intensities, and electric and acoustic filters. A given tone was varied in intensity under a constant frequency and a second tone of constant slight strength was adjusted to the first tone by the person used in the test. The apparent deepening increases with the strength of the sound and decreases on progressive frequency (between 200 and 3,000 hertzian waves). It is of different magnitude in different persons (up to 100 per cent), and sometimes may reach a half tone. Overtones,

14. Zurmuhl, G.: Ztschr. f. Sinnesphysiol. **61**:40, 1930.

unless they are heard separately, draw the fundamental tone upward, especially in very soft and very loud sounds. In loud tones, a secondary tone of the character of a combination tone is still heard below the primary tone; its distance from the primary tone varies with the strength of the latter. Deepening of the tone is less in one ear than in both ears. The explanation is as follows: By closing the ear, a weak stimulation can never be excluded; the weakly deepened tone in the closed ear and the strongly deepened tone in the unclosed ear produce the phenomenon of moderate height of tone. This explanation is confirmed by special tests: When a diotic tone is gradually weakened, on one side, the apparent height of the tone is increased. Like the pitch or height of tone, the so-called sound color was also found to differ in the right and left ear. The differentiation-sensibility for frequencies was considerably greater diotically than in one ear. The phenomenon of tone deepening can be understood only on the basis of the Helmholtz resonance theory; granted that the radial fibers vibrate like tense strings, their own frequency must increase with a growing amplitude, and the maximal resonance will then become displaced in the apical direction to more deeply attuned fibers. The occasionally observed slight heightening on strengthening of the sound is evidently due to psychic factors.

Wilkenson,[15] in an ingenious manner, attempted to measure the vibration period of the basilar membrane as represented in its natural condition in the cochlea. He stated that the immersion of the basilar membrane in fluid causes a large reduction of the frequencies of the vibrations of its various sectors throughout the scale. The reduction is somewhat greater at the distal than at the proximal end of the scale.

The natural period of vibration when the membrane was not immersed in fluid was 250 double vibrations a second; this was reduced to 37.5 double vibrations by the addition of fluid of a total length of 4 cm. In other cases the loss was less, and in a few even greater. Thus no definite mathematical expression of the value of the fluid load for each part of the membrane could be formulated.

The fluid load cannot be considered merely as so much mass added to the mass of the membrane itself, for although the relative lowering of the pitch is in agreement with this theory, the absolute lowering is considerably less than is anticipated.

Pohlman [16] suggested that the morphology of the middle and internal ear be interpreted not only in relation to the function of transmission and analysis of sound, but also from the standpoint of a shock absorber system. The development of the internal ear assures an acoustic insulation because it is an immersion receptor. This insulation is overcome by the sound transmission apparatus which compensates for the differ-

15. Wilkenson, S.: Acta oto-laryng. **14**:134, 1930.
16. Pohlman, A. G.: Anat. Rec. **3**:236 (April) 1930.

ences between air and water. Pohlman measured the efficiency of insulation on the basis of lowered air acuity, in cases in which the apparatus for the transmission of sound was out of commission; this may be represented by a factor 3,000 and 10,000 times the normal threshold intensity. The evidence shows that leverage action of the ossicular chain is not related to transmission of sound and that the round window is not essential to analysis of pitch or to the sensitivity of the end-organ response.

Guild [17] reported an interesting anomaly that is not explained by the accepted theories of hearing: In one ear of a colored man, 38 years of age, a large bony septum was seen between the lower half of the middle turn and the apical turn of the cochlea. Four weeks prior to death his hearing was normal for all tones up to 8,192 double vibrations. This anomaly was not associated with any defects of the nerve, as had heretofore been reported. If the usually accepted theory of hearing is true, that sound waves in the perilymph pass up along the scala vestibuli to the helicotrema and then down the scala tympani, this opening in the cochlea would permit such sound waves to pass below the helicotrema. Were this theory sound the anomaly would have caused such interference with the wave system as to interfere seriously with hearing, especially that of low tones. In this instance the threshold for low tones was actually better than average.

Pearcy [18] concluded that the basilar membrane, in the substance of which the unbranched cochlear artery passes, is actively concerned in audition. Acuity of hearing is in direct proportion to the tonus of the vessel, being retarded in vasodilation and increased in vasoconstriction.

A number of adults were given from 2 to 4 Gm. of sodium nitrite, and the blood pressure and audiometric readings were recorded. The vasodilation increased the load of the basilar membrane, resulting in the diminution of function. From 15 to 30 minims of epinephrine was then given, and similar readings made. The vasoconstrictor action decreased the load of the basilar artery, resulting in increased auditory function.

PHYSIOLOGY OF THE MIDDLE EAR

In an extensive study of the physiology of hearing, including experiments on the mechanism of the auditory ossicles and their behavior toward sound and air pressure, Dahmann [19] arrived at the following conclusions:

1. When the proper technic is used, preparations of the middle ear may be obtained, which enable one to study the movements of the malleus, incus and stapes as well as the posterior half of the tympanic membrane up to the umbo, in spite of an intact chain of auditory ossicles

17. Guild, Stacy, R.: Anat. Rec. **3**:217 (April) 1930.
18. Pearcy, J. F.: Am. J. Physiol. **91**:8 (Dec.) 1921.
19. Dahmann: Ztschr. f. Hals-, Nasen- u. Ohrenh. **24**:462, 1929.

and a connection with the labyrinth and aural muscles. 2. Numerous curves were obtained. 3. All auditory ossicles were found to respond to high sounds; to very high sounds produced by a whistle, the response was of such an extent that it could be measured. 4. The oscillations of all the ossicles were in various planes, although an oscillation in one plane predominated; this corresponded to the outward movement of the handle of the malleus, with oscillations in a common axis. 5. When correspondingly strong stimuli were used, slight lateral movements were registered. 6. The ossicles were moved in a different direction by the contraction of the internal aural muscles. 7. A weaker stimulus is followed by external rotation of the auditory ossicles, and a stronger stimulus is followed by an internal rotation; this holds true for air pressure in the auditory meatus as well as for sounds of various intensity. 8. In the presence of an intact chain of ossicles, the reaction to air pressure and to sounds of sufficient intensity is in the form of a decrease of the angle between the malleus and incus, and the stapes. 9. In the presence of a labyrinthine stimulus the oscillations of the hammer and incus are of the same extent, even if the rotation of the angle is considerable; only when there is an extensive influence on the tympanic membrane and corresponding rotation of the hammer does the incus remain behind the malleus. 10. If the oscillation of the chain is so slight that the stapes can follow it, and if the combination of the ossicles with each other is sufficiently strong to offer more resistance than the degree of fixation of the stapes in the fenestra ovalis, the oscillation of the entire chain of ossicles occurs "en masse." 11. The decrease in amplitude during the transmission of the movement from the malleus to the stapes, in the presence of an intact chain, cannot be explained by the law of levers, but apparently is related to the separation of the chain from the labyrinth. 12. The decrease of the angle of rotation between the malleus and stapes can be explained only by the resistance in the tense chain, which is due to the elastic connection between the auditory ossicles. 13. In the transmission of strong oscillations, the chain does not represent a firmly closed mass. 14. A record of the vocal sound picture enables one definitely to recognize the various oscillations of the ossicles to various sounds; the results obtained agree fully with those of functional tests. 15. A variable degree of loudness does not condition any change in the vocal picture, but only presents one of a different size; i. e., the width but not the plane of oscillations is changed. 16. The functions of the tensor tympani are: (*a*) tension of the tympanic membrane and consequently of the chain whereby the amplitude and the tone intensity are decreased (protection against loud noises); (*b*) regulation of the plane of oscillation of the malleus by an effect on the lateral movements, and (*c*) an apparent influence on the tone of the tympanic membrane by a change in the tension of the latter. 17. The stapedius muscle

by its contraction makes the auditory ossicle chain tense, decreases the width of the oscillations and decreases the intensity of the sound. In this sense it can be considered as a synergist of the tensor tympani. 18. The anatomic structure of the ossicles and their combination with each other is purposeful and can be demonstrated by registration of the movements of the ossicles. 19. By means of an optic kymograph, vocal curves can be obtained from the pars tensa of the tympanic membrane as well as from the malleus. Whether these vocal pictures themselves are sufficient for the explanation of the actual physiologic relations must be determined by other experiments. The latter must deal with the mode of oscillation, the ability of oscillation of the tympanic membrane, a study of its own tone and the problem of whether or not the tones of the tympanic membrane show a proper periodicity. 20. A study of the individual curves and vocal pictures enables one to answer some of the problems mentioned.

In the evaluation of the results obtained, the following points must be determined: (1) geometric and practical proof that the deviation of the mirror from the axis of rotation did not influence the results; (2) that the measurement of the distance of the mirror was precise; (3) the anatomic axis and the length of the lever of the auditory ossicles; (4) the intensity of the sound according to the subjective degree of sensitivity; (5) constancy of the intensity of sound for comparative measurements; (6) the effect of the lever, and (7) various points associated with dynamics, such as the gain or loss of energy during the conduction of the sound stimulus.

Luscher,[20] in previous investigations of the function of the stapedius muscle in man, showed that cochleostapedius reflexes occur regularly. This is true not only in the presence of abnormally intense acoustic stimuli but also in the ordinary intensity of sounds and noises in daily life.

On a suitable subject he carried out further experiments on the properties of the stapedius reflex. The results may be summarized as follows: 1. Studies by means of an aural microscope were carried out in a person in whom the stapedius tendon could be seen through a defect in the tympanic membrane. 2. There could be demonstrated a regular and constant cochleostapedius reflex. All the author's previous observations were confirmed. 3. The stapedius reflex in the human being shows considerable individual variations, as does the tone-region within which the reflex can be produced. The same is true of the threshold value; in the present case it occurred between 650 and 12,000 D. Sch. 4. The stapedius reflex occurs also in osteotympanic conduction of sound. It cannot be produced by vibratory rhythmic stimulation of the sensory nerves. 5. The stapedius reflex may become "fatigued" by

20. Luscher, E.: Ztschr. f. Hals-, Nasen- u. Ohrenh. **25**:462, 1929.

continuous sounds, and reflex deafness appears after from one to one and a half minutes. The "fatigue" is dependent on the height of the tone and lasts longer when high sounds are used. It affects only a particular tone, while for other tones the reflex is not fatigued. 6. The reflex irritability returns after a few minutes. 7. A comparison with the fatigue of the sense of hearing shows that the auditory organ has two regulatory or protective mechanisms: It has a neuromuscular apparatus, the stapedius reflex, which occurs and acts with a great intensity, regulating the conduction of stimuli; it also has the property of transformation of the stimulus, which, according to Kries, develops slowly and increases the intensity of the process of stimulation in the organ of perception. The reflex precedes the process of transformation. 8. The fatigue of the reflex affects the sensory portion of the reflex arc and is apparently situated peripherally. 9. The stapedius reflex shows the specific biologic effectiveness of high tones.

Kobrak [21] investigated the physiology of the inner muscles of the middle ear. In many recent works these inner muscles in man have been described as rudimentary and incapable of active function. Other writers attribute a specific function to them.

To determine the physiology of these muscles three fundamental problems must be solved: (1) Do the muscles participate actively in the act of hearing? (2) What is their task? (3) In what manner is this act carried out by the muscles?

Investigations were carried out on animals, and then an attempt was made to apply the results to the middle ear of man.

Kobrak discussed chiefly the first problem. On the basis of these experiments the statement made in old textbooks about the antagonism of the two muscles is hardly correct. The author did not believe that the antagonism observed by Kato can exist physiologically. During the act of hearing, both muscles are simultaneously active and in this relation are therefore synergistic.

I should like to add a great many other observations by Kobrak, but in a sense they are similar to those of Luscher, and substantiate, in great part, the observation that the muscles participate actively in the act of hearing. In these experiments he found that a definite stimulus gives rise to a definite height of contraction. Under this mechanism an accommodation could be assumed, and it would be easy to ascribe to the tensor tympani a variable influence on the tympanic membrane and the chain and therefore also on sound conduction. Through the contraction, sound conduction may be quantitatively changed (accommodation according to intensity). Kobrak did not believe it possible for the sound-conducting chain to adjust itself to the tone frequency by a change

21. Kobrak, H.: Beitr. z. Anat., Physiol., Path. u. Therap. d. Ohres **28**:138, 1930.

in its own oscillations. He demonstrated experimentally that the same contraction could be obtained from the high and not loud tone as from the low but loud tone. The strength of contraction therefore depends on frequency and intensity. These two factors may vary without affecting the muscular effect, on condition that with a variation in one factor a corresponding opposite variation in the other factor takes place.

Kobrak also undertook to measure the movements of the tympanic membrane resulting from contraction of its muscles. In numerous animals, in which the muscles were definitely functioning, it was shown by control through an open tympanum that the tympanic membrane was not moving. This corresponds to the direct observation by Waar and Luscher that there is no visible movement of the tympanic membrane during the presence of acoustic stimuli. It seems probable that in man there is a definite function of the aural muscles. These observations are in agreement with those of Luscher and others.

PHYSIOLOGY OF THE LABYRINTH

Van den Branden,[22] in an attempt to corroborate the observation that an increase of endolymphatic pressure leads to an excitation or a paralyzing action on the semicircular reflexes, trephined the temporal bone, exposing the external wall of the internal ear; after creating a window in the promontorium and connecting a pipet filled with Ringer's solution, he found that a pressure of 1 cm. of mercury caused an oblique homolateral nystagmus. A pressure of from 2 to 4 cm. caused disordered movements of the eye. He concluded that an increase of the endolymphatic pressure increases the semicircular irritability.

Spiegel,[23] in a number of articles, related his experimental studies of the nervous system. The present one deals with the mechanism of labyrinthine nystagmus. He stated that in studying the physiology of the labyrinth one must consider that a continuous stimulus applied to the semicircular apparatus produces a discontinuous rhythmic reaction, the nystagmus. An attempt has been made to explain this phenomenon by the assumption of the presence of a center for the rapid phase of the nystagmus; that the slow phase of the nystagmus can be explained by the tonic labyrinthine reflex which leads to a tonic deviation of the ocular muscles, produced by a weak labyrinthine stimulation, and that the rapid phase observed in pathologic stimulation of the labyrinth is due to the interruption of the tonic deviation of the eyes at regular intervals.

Even if a center for the rapid component of the nystagmus was present, the problem could not be considered as solved, because the question would arise as to how this center regulates the stimuli at definite intervals. Some authors are of the opinion that the rapid component

22. van den Branden, J.: Compt. rend. Soc. de biol. **103**:507 (Jan. 25) 1930.
23. Spiegel, E.: Ztschr. f. Hals-, Nasen- u. Ohrenh. **25**:200, 1929.

of the nystagmus is of orbital origin. A number of experiments were carried out by Spiegel in order to solve this problem. The results may be summarized as follows:

1. In the region of the central nervous system in which the vestibular nystagmus is presumed to occur (the caudal portion of the vestibular nuclei, the cranial portion of the mesencephalic ocular nuclei and the proximal portion of the brain stem), an attempt was made to localize the point of origin of the rhythm responsible for the nystagmus.

2. Experiments with a unilateral section of the vestibulomesenteric tracts (on the right) and extirpation of all the external ocular muscles on the opposite side (left) up to the internal rectus muscle showed that the transmission of the vestibular stimulation in the region of the oculomotor nuclei where the longitudinal bundle was still maintained (left) was not sufficient for the production of contraction and relaxation of the muscles of the opposite side by the opposite internal center. It was therefore concluded that the nuclei of the ocular muscles are not the point of origin for the rhythm which leads to the production of nystagmus.

3. Extensive bilateral destruction of the substantia reticularis does not prevent the occurrence of horizontal or vertical rhythmic ocular oscillations by means of a rotation stimulus. The assumption of a center for the rapid component of the nystagmus in the substantia reticularis is therefore not substantiated, since the nystagmus may be obtained even by means of transmission of vestibular impulses leading to nystagmus to the mesencephalic nuclei of the ocular muscles and even after a bilateral separation of the posterior longitudinal bundles (i. e., through the vestibulomesencephalic system coursing in the substantia reticularis).

4. On the basis of exclusion, it was possible to localize the rhythm that is the basis for the vestibular nystagmus; therefore both components of nystagmus were in the vestibular nuclei themselves. The rhythmic alternation in the state of irritation of the right rotators of both eyes and the corresponding relaxation of the antagonistic muscles is to be ascribed to processes of innervation within the vestibular nuclei.

In a former work Blohmke [24] found that electric stimuli of the surface of the thalamus at the point where it merges with the anterior corpora quadrigemina produced nystagmus. At that time questions arose as to the nature of the physiologic stimulus and as to the pathways involved from the thalamus to the ocular nuclei.

As to the first question, it can be said that the thalamus has some relation to the vestibular nuclei; only nystagmus of the labyrinthine type is invoked. In investigating the pathways the author followed the

24. Blohmke: Ztschr. f. Hals-, Nasen- u. Ohrenh. **24**:520 (Oct.) 1930; abstr., Arch. Otolaryng. **11**:513 (April) 1930.

method of Lorente de No. He argued the probability that the impulses go from the thalamus caudalward, are worked over in the formatio reticularis in the midbrain and the pons, and go forward to the oculomotor centers; also that the thalamus represents the most oralward of the nervous system for the production of the nystagmus, a system of neurons which extends through the medulla, pons and midbrain. In this system the higher functions lie in the oralward, and the lower in the caudalward, nuclei.

Alfandary [25] gave an interesting exposition of Leidler's experimental work on rabbits. The brain of each animal was carefully examined histologically in a study of the relations between the apparatus of hearing and the cerebellum or brain. The technic consisted of the removal of fragments or entire organs. In studying the midbrain, punctures were made in the floor of the fourth ventricle. The results were: 1. The direction of the nystagmus varies with the height of the lesion; low lesions produce a homolateral nystagmus, middle or high lesions a contralateral nystagmus. 2. The form of the nystagmus also varies according to the height of the lesion; rotary nystagmus appears in low lesions, horizontal nystagmus in middle lesions and vertical nystagmus in high lesions.

The functional relations of the vestibular apparatus with the cerebellum have been the object of a large number of investigations the results of which are: 1. When the cortex is removed without injury to the central nuclei of the cerebellum no spontaneous nystagmus occurs, and there are no modifications of the nystagmic reactions during and after rotation. 2. When the entire cerebellum is removed there is no spontaneous nystagmus, but the nystagmus produced by rotation is modified. During the first few days following the operation, when the revolving table is stopped there is a nystagmus which, instead of beating toward the opposite side, beats toward the side of rotation. After a few seconds this nystagmus is reversed. 3. The postrotary nystagmus is so rapid that it becomes impossible to distinguish the slow phase from the rapid phase. 4. In some cases, after cessation of the postrotary nystagmus, a nystagmus appears in the same direction as the nystagmus prior to rotation. 5. The removal of one half of the cerebellum produces a hyperexcitability of the vestibule on the affected side. 6. The removal of a cerebellar hemisphere does not have any influence on spontaneous or provoked nystagmus. 7. The relations between the vestibular apparatus and the cerebral hemispheres have not been studied to any great extent. Bauer and Leidler have performed experiments with the following results:

(*a*) The removal of the cerebral hemispheres and the thalamus did not have any effect on the nystagmus. (*b*) The removal of a single

25. Alfandary, I.: Rev. d'oto-neuro-ophth. **7**:734 (Dec.) 1929.

cerebral hemisphere produced homolateral hypo-excitability and contralateral hyperexcitability.

De Juan [26] conducted experiments (1) to compare the strength of the currents and displacements produced through the aspiration and compression of the contents of the vertical semicircular canals, anterior and posterior, according to the different positions of the head in space, and (2) to determine the direction of the nystagmus induced through compression and aspiration of the contents of the anterior and posterior semicircular canals. The technic and protocols of the experiments will be published shortly. The author reached these conclusions: Variations of pressure act on a fistula in the left anterior semicircular canal as follows: 1. Variations of pressure on the anterior and posterior vertical semicircular canal give rise to nystagmus of considerably less intensity than do variations of pressure on the horizontal canal. 2. Rabbits show considerable differences in the anterior vertical canal. 3. Pressure acting on a fistula in the left anterior semicircular canal, with the head in the normal position, causes a less marked nystagmus than that produced by aspiration. Pressure and aspiration give rise to similar horizontal backward nystagmus, but differ with respect to the accompanying vertical and rotary components. (The contractions of each of the ocular muscles must be registered. 4. With the head on the right side at an angle of 60 degrees (left anterior vertical canals), aspiration (with the current away from the ampulla) gives rise to a more violent nystagmus than does pressure (with the current toward the ampulla), and one of greater intensity than when the position of the head in space is normal. 5. With the head inclined 20 degrees downward, in the left lateral position, pressure induces a stronger nystagmus than aspiration. 6. Nystagmus caused by variations of pressure in the anterior vertical canal does not occur in the direction of the canal; on many occasions, the nystagmus is even horizontal. 7. When pressure acts on the posterior vertical canal, the results are always identical, and do not vary from one rabbit to another as when the anterior vertical canal is acted on. 8. When pressure is exerted on the contents of the left posterior vertical semicircular canal, aspiration always gives rise to a more violent nystagmus than that of compression, but indicative of an important dependence with respect to the position of the head in space. 9. The nystagmus produced by pressure on the posterior vertical canal never occurs in the direction of the stimulated canal. 10. The great difference in the intensity of the nystagmus produced by stimulation of the horizontal canal and the vertical canals seems to indicate that the three canals are not functionally equivalent; perhaps the vertical canals have, at least in part, another function than do the external semicircular canals. 11. Ewald's law possesses only a relative value, for according to the position occupied by the

26. de Juan, P.: Acta oto-laryng. **14**:337, 1930.

head in space, the currents from and to the ampulla will give rise to quantitatively distinct results. (According to Ewald's law, the current to the ampulla has twice the intensity of the current away from the ampulla.)

Meurman,[27] in a series of experiments, created fistulas in the scala tympani through which he inserted a manometer and injected Ringer's solution intraspinally and into the cisterna, thereby increasing the intraspinal and intracranial pressure. He noted that although the intralabyrinthine pressure was likewise increased there was no nystagmus. He concluded that this was due to the fact that the increased pressure is conducted equally to both ears. With a decrease of pressure, produced by many trephinings in the wall of the scala tympani and vestibuli, he noted that an overflow of the perilymph did not produce nystagmus.

When intracranial pressure is raised and there is some superadded factor which, together with the raised pressure, provokes nystagmus, the latter will be present approximately as long as the pressure remains raised. Accordingly, an increase in previously normal intracranial pressure can prevent spontaneous nystagmus, directed to the opposite side of the irritated labyrinth.

In a second series of experiments he created fistulas into the scala tympani or scala vestibuli through the promontory, fixed a capillary pipet filled with Ringer's solution in these openings and, by means of a rubber cap, squeezed about 0.5 cc. of the solution into the inner ear. He observed that on compression a nystagmus to the same side (or at least a preliminary deviation of the eye to the opposite side) occurred. When suction was applied to the same cavity the peak of the effect seemed somewhat different, depending on the site of the acting point. Fairly strong suction was required to produce a nystagmus to the opposite side when applied to the scala tympani or scala vestibuli. Furthermore, a nystagmus to the same side might persist during suction from these points if compression had preceded it.

When suction followed compression from the perilymphatic space of the semicircular canal, the deviation and nystagmus produced by compression immediately disappeared. In rabbits the cochlear aqueduct has a marked influence on these phenomena. It is probable that the membrane that separates the upper from the lower part of the labyrinth also plays a part. It is probable that the macula of the saccule aids in effecting pressure nystagmus.

Thornval's [28] observations on otolith nystagmus in pigeons is interesting. He stopped up the semicircular canals of the pigeon and then by blowing air into the vestibule, provoked a perfect and typical reflex movement, a nystagmus with the slow phase forward in the plane of the

27. Meurman, T.: Acta oto-laryng. **13**:552, 1929.
28. Thornval, A.: Acta oto-laryng. **14**:333, 1930.

anterior vertical canal on the same side, and the rapid phase backward in the plane of the same canal. Suction produced no reflex movement. The nystagmus movement was, no doubt, produced by the vestibular apparatus. The reflex movement was always of the same nature and was never elicited with the canals open. He attributed this to the fact that the movement of endolymph is toward the otolith membranes and, most likely, toward the macula utriculi. The movement was not influenced by the position of the head of the pigeon. Thornval then extirpated the ampulla of the posterior vertical canal and repeated the experiment. The movement was also present, but in some cases the sucking of air also provoked a movement with the slow phase backward toward the side not operated on, and the rapid phase forward toward the side on which the operation had been performed. The author attributed this movement to the macula utriculi.

He next removed all the ampullae, but this was accomplished with a great deal of injury to the utricle. Subsequently, in the majority of cases the reflex movements could not be elicited on the introduction of air, although in a few instances feeble but unmistakable reflex movements could be detected in the same direction as in the preceding experiments. Suction produced no movement. The author was certain that all these movements originate in the utricle and that the saccule does not participate in any way.

The caloric tests were performed similarly. A reaction was elicited after all the semicircular canals were filled. This reaction did not include any reversion by forward inclination of the head. When both the ampulla and the membranous part of the posterior vertical cord were removed, the nystagmus disappeared, although it was still present in the stopped horizontal canal. After all ampullae were removed, no reaction could be elicited.

Thornval concluded that the caloric reaction in pigeons originates chiefly in the semicircular canals, and that normal canals are necessary for the appearance of normal caloric reactions with reversions. This does not necessarily imply that the otolith organs are not susceptible to caloric irritants or that they do not influence the caloric reaction.

Tait and McNally,[29] in a group of cleverly conducted experiments, studied the control exerted by the semicircular canals on the limbs and bodily musculature of frogs. By ablation and the use of a special tilting table equipped with writing levers in contact with a kymograph, they made the following observations: 1. The reactions of a frog to turning about on a vertical axis were in response to two factors: acceleration and centrifugal force. 2. The tendency to turn in the opposite direction to that of the rotation was in response to angular acceleration and was

29. Tait, J., and McNally, W. J.: Ann. Otol., Rhin. & Laryng. **38**:1121 (Dec.) 1929.

elicited from the semicircular canals. 3. The tendency to lean toward the center of the turning table was in response to centrifugal force and was most probably due to the utricles. 4. One vertical semicircular canal influenced the protective response of all four limbs to rapid tilting in the plane of that canal and in the direction in which its ampulla pointed. 5. One posterior semicircular canal elicited a response from the flexor muscles of both ankles, but more markedly from the muscles of the same side. 6. The response of the muscles to the semicircular canal stimulation was "twitchlike" and extremely rapid. The frog did not show the labyrinthine head-righting reactions which Magnus described in the mammal. 7. The labyrinthine reflexes were affected by reflexes from other parts of the body, which supplemented or modified them in controlling the posture and movements of the normal frog.

Portmann [30] experimented on four dogs to study the action of compression and ligation of the large vessels of the neck on the vestibular reactions. In the first, the primary carotid artery was ligated, in the second both vertebral arteries were ligated, in the third the two vertebral arteries were ligated and sectioned, while in the fourth a permanent ligature was applied to the left vertebral artery and temporary ligatures were placed on the right vertebral artery and the common carotid on the same side.

The author drew the following conclusions: 1. Rotation tests made on several different occasions before and after ligation of the common carotid artery did not show any notable change in the production of nystagmus. 2. Rotation tests made before and after ligation of the vertebral arteries did not show marked modification in the production of nystagmus. 3. Rotation tests before and after ligation and resection of the vertebral arteries did not show appreciable changes in the nystagmus. 4. Rotation tests made before operation or after ligation of the left vertebral artery alone, both vertebral arteries or both these arteries and the right common carotid at the same time did not produce any appreciable modification of nystagmus.

These experiments show that mechanical modification of the intracranial circulation does not have any effect on the vestibular reflexes, at least in the dog.

Huizinga [31] investigated the galvanic reaction of the vestibular apparatus in the pigeon. The galvanic examination revealed in the normal pigeon approximately the same results as those described by Jensen. However, the marked deviation of the head to more than 90 degrees was not observed. The slow tonic deviation of the head in the case of a weak current is characteristic. Numerous secondary reactions

30. Portmann, G.: Acta oto-laryng. **14**:303, 1930.

31. Huizinga, E.: Arch. f. d. ges. Physiol. **224**:569, 1930.

with a stronger current have no value in the examination of the vestibular nerve.

After bilateral extirpation of the labyrinth, the galvanic reaction can be evoked normally, though it usually shows decreased intensity. Gradually, however, the galvanic reaction becomes reduced to a minimum. Microscopic examination showed that this phenomenon must be explained by the assumption of a progressive degeneration of the vestibular nerve and of Scarpa's ganglion. The galvanic excitation probably is not brought about by the irritation of the peripheral labyrinth, but by irritation of the nerve.

In pigeons in which the labyrinth on one side had been removed long before, it could be demonstrated that cathodal and anodal irritation gave nearly the same result.

Removal of a portion of the labyrinth impairs the galvanic reaction to a lesser degree than does removal of the entire labyrinth. Even after a long period, however, after degeneration of the nerve must already have set in, a normal galvanic reaction of the inferior as well as of the superior part can be evoked.

Besides the galvanic nystagmus of the eyes, tonic deviation of the eyes also occur, especially in a vertical direction. The eye as well as the head becomes displaced in the direction of the anode.

Lorente de No [32] reviewed a considerable part of his work in one of the Latin American journals. He gave some of his conclusions in regard to the anatomy and physiology of the vestibular nerve and vestibular apparatus. I only quote some of them briefly as his work has previously been reviewed in the ARCHIVES.

Lorente de No stated that the following facts are indisputably proved: 1. The semicircular canals produce nystagmus. 2. They produce reflexes to accelerate movement in one direction. 3. They are concerned in the production of turning reactions. 4. They are concerned in the production of tonic ocular reflexes.

The first fact depends on endolymphatic currents, and the remaining three on displacements of the membranous canals within the bony canals.

Regarding the otolith system, he contended that the maculae are organs that react slowly to changes in position of the head in space. He rejected the theories of Quix, Magnus and de Kleijn as incapable of experimental proof.

His own theories include the following: Each crista is surrounded by a zone of rather solid attachment to the bony canal, while the crista itself and the remaining membranous canal are loosely contained within the bone. Hence, dislocation of the membranous canal within the bone is readily effected, while the crista may move up and down but not

32. Lorente de No, R.: Rev. españ. y Am. de laryng., rhin. & otol., Nov., 1929.

laterally. Stimulation of a macula is impossible unless deformation of the corresponding otolithic membrane can be produced. He likened such deformation to the change in shape of a drop of liquid lying on a surface, without a change in area when the surface is tilted about.

From his comparative studies of the labyrinth in fish, Werner [33] concluded that the macula is divided into two distinct parts: an anterior portion with a high epithelium, not covered with otolith, and a posterior portion with a low epithelium, covered with otolith. Often both parts are innervated by separate nerves. For this reason he could not agree with Magnus and de Kleijn, who held that the stimulation of the macula is produced by pulling on the hair cells. Were this true the uncovered part of the macula would receive no impulses. Their theory of hydrostatic pressure as the causative agent for stimulus response, on the other hand, meets the foregoing objection and has been proved experimentally to their satisfaction. In this way both parts of the macula receive opposite stimuli: one positive and the other negative.

POINTING TEST

Malan [34] described a graphic method of registration of postrotary deviations in the pointing test. His purpose was merely to state the results furnished by the pointing test in normal persons. The 400 persons examined by him were all candidates for aviation who had already undergone all the preliminary tests of physical fitness; all were men between 20 and 30 years of age, who presented no anatomic or functional change in the auditory apparatus. In tests of the vestibular system and sensibility to causes productive of vertigo, the author limited himself to a systematic examination of the nystagmic and general reactions on rotary stimulation. In the persons examined, different types of deviation were observed: (1) the classic deviation of Bárány, the direction of which is in inverse relation to that of the rapid phase of postnystagmus; (2) inverse deviation as compared to the preceding type; (3) convergent or divergent deviation, and (4) irregular deviation. At the first glance, the first type would seem to be the most frequent, but it was distinctly noted in only 20 per cent of the cases, nearly all of which presented signs of hypersensibility on auditory stimulation. The inverse type (5.8 per cent) was constantly found in persons with normal postrotary reactions. The divergent type (17.5 per cent) indicates a hypersensibility to rotation, which becomes proportionately more accentuated during the test. The convergent type (7.5 per cent), which exists only in normal persons, indicates a progressive adaptation to the stimulus and a voluntary or automatic correction of the subjective phenomenon of

33. Werner, C. F.: Ann. Otol., Rhin. & Laryng. **39**:101 (May) 1930.
34. Malan: Rev. de laryng. **51**:405 (June 30) 1930.

rotary vertigo. The irregular type is interesting especially from the medicolegal point of view, for it was shown by psychopathic persons as well as by malingerers. Not uncommonly (15 per cent), mixed reactions were noted in which a classic reaction occurred after the first series of rotations, and no reaction after the second series, or vice versa; or perhaps a divergent reaction was noted first and a convergent reaction later. Mixed reactions are the indication of a different susceptibility to rotation according to direction. In about thirty cases, there was no postrotary deviation; this is observed exclusively in persons without any secondary phenomenon on rotation. The author also investigated the pointing deviation during the rotation; in normal persons the deviation regularly occurred from the direction of the rotation. This would be entirely in conformity with the law of Bárány, the deviation occurring in the opposite sense to that of postrotary nystagmus. The graphic method of registration seems to the author to possess certain advantages. In the first place, the person has absolute control of the errors committed by him, which is not the case in tests applied according to the classic method of Bárány. When the person has not accomplished the objective of his pointing, he will modify his reaction, consciously or not, in order to correct his error; with the author's method, there is no mental correction and the cerebral participation is reduced to a minimum. Furthermore, the graphic test permits a detailed analysis of a series of factors which necessarily disappear in the classic test. Finally, the graphic method demonstrates a pointing type which has not previously been described, namely, the crossed reaction. This reaction is preferably found in persons with a fatigued nervous system and may eventually be interpreted as due to a voluntary hypercorrection. The technic of the graphic method is simple and does not require complicated apparatus like those proposed by Talpiss (photographic method) or Miodonski. It is easy to convince oneself that in normal persons the graphic test gives rather different results from those obtained by the original Bárány method. So many different factors enter into each of these tests that it is difficult to determine the true cause of the divergence.

THE VASOMOTOR PHENOMENON

Muck [35] described transitory vasogenic hypacusia following caloric stimulation of the labyrinth. By caloric stimulation of the labyrinth of persons with healthy ears who give a normal reaction in the so-called epinephrine sound experiment, it may be shown that after the stimulation the vasoconstrictor nasal phenomenon can be obtained. The white striae appear after irrigation of the ear with cold water, either only on the side irrigated or on both sides. When the ear is irrigated with hot

35. Muck, O.: Ztschr. f. Hals-, Nasen- u. Ohrenh. **25**:262, 1930.

water, the white striae appear, as a rule, on the opposite side. The vasoconstrictor nasal reflex phenomenon is absent in cases of complete deafness when the labyrinth is no longer stimulable calorically. If the labyrinth is still stimulable, the white nasal striae can be demonstrated. From these determinations, the conclusion was drawn that vasoconstrictor processes of the auditory artery must participate in the calorically produced nystagmus. The attempt was made to determine whether the function of the cochlear nerve can also be transitorily influenced by the caloric stimulation. By irrigations with cold water, an effort was made to determine whether the portion of the labyrinth is influenced vasomotorially by the caloric stimulus. The tests were carried out by means of tuning fork *C 5*.

The experiments were carried out on physicians, from 30 to 32 years of age. Before the experiment it was determined whether the duration of hearing for *C 5* was the same in those performing the tests and in those tested. In a number of persons it was found that the duration of hearing for *C 5* was shortened by seven minutes on the average, after cold stimulation, and by two to three minutes, on the average, after irrigation with hot water.

After caloric stimulation of the labyrinth, therefore, a transitory hypacusia appears which can be demonstrated by means of a tuning fork *C 5* on the same side when cold water is used for irrigation and on the opposite side when hot water (45 C.) is used for the irrigation. The question whether this transitory hypacusia is to be explained by a cramp of the ramus cochlearis remains undetermined. The latter seems probable, however, because after hot irrigations the vasoconstrictor nasal reflex phenomenon and the hypacusia are demonstrable on the non-irrigated side.

Abstracts from Current Literature

Ear

AGENESIS OF THE EAR AND CONGENITAL CYANOSIS. JUAN CÓRDOBA, But. de la Soc. Catalana de pediat. **1**:31 (April) 1928.

A case of combined congenital absence of one ear and congenital cardiac lesion is presented. In a discussion of congenital defects, the author states that the frequent occurrence of other congenital lesions with a congenital cardiac defect is evidence against the inflammatory theory of the origin of the latter. The patient also had a megacolon, which the author thinks may have been a congenital defect.

WATSON, Milwaukee.

TREATMENT FOR OTITIS AND MASTOIDITIS IN INFANCY. LUDWIG F. MEYER, Kinderärztl. Prax. **1**:28 (Sept.) 1930.

This discussion of the treatment for otitis media and mastoiditis in infancy is opened by Meyer, who takes a conservative attitude toward myringotomy and mastoidectomy and questions the existence of so-called masked mastoiditis. Finkelstein continues the discussion by denying that he has become radical even though he insists that masked mastoiditis is an entity, if a comparatively rare one. The problem is further debated by Freund, Nobel, Amersbach, Kobrak, Alexander, Bessan, Engel, Lugenbühl and Wolff. Meyer sums up the discussion with the statement that the old conservative methods are not outmoded, but that an open-minded attitude should be taken as to the existence of masked mastoiditis.

HUENEKENS, Minneapolis.

HYDROSTATIC PROPERTY OF LABYRINTH AND FUNCTION OF DUCTUS ENDOLYMPHATICUS IN FISH. C. F. WERNER, Ztschr. f. Hals-, Nasen- u. Ohrenh. **26**:444 (Sept. 20) 1930.

Werner's experiments on elasmobranchii indicated that the open ductus endolymphaticus serves for absorption of otolith gravels, elimination of endolymph and conduction of water pressure in the labyrinth. The function of the labyrinth is presumably hydrostatic; the theory is based on Wittmaack's statements concerning irritation phenomena observed in the labyrinth, on researches in bone fish and on Portmann's experiments in rays. The macula sacculi serves probably as an absorption organ; this is indicated by its location and because no other function of the macula could be ascertained.

EDITOR'S ABSTRACT.

NEOFORMATION OF BONE IN THE LABYRINTHINE CAVITY IN CASE OF DESTRUCTION OF LABYRINTH AND MENINGITIS. G. THEISSING, Ztschr. f. Hals-, Nasen- u. Ohrenh. **26**:451 (Sept. 20) 1930.

In Theissing's case, that of a woman, aged 27, the disease was of thirteen months' duration, beginning with an acute otitis media on the right side. Six months after onset, antrotomy was performed. A radical operation was performed three months later because the discharge persisted; dizziness developed immediately following operation, lasting five weeks. In order to promote healing of the operative wound, the patient was exposed to sun radiations. The last exposure of five hours' duration, took place eight days prior to admission to the hospital and was followed by a severe headache; vomiting developed the next day. On examination, a discharge proceeding from the operative cavity and a fistula located on the operative scar, were found; the ear was deaf and did not respond to caloric irritation. Roentgenograms demonstrated an extended defect of the labyrinthine

bone. Neurologic examination testified to meningitis; fever and leukocytosis (20,000) were present. Lymphocytosis and a positive Pandy's reaction were found in the cerebrospinal fluid. The operative cavity was exposed, and granulations were found in the tympanic region; no macroscopic changes were detected in the wall of the sinus or in the dura of the cerebellum and the middle cranial fossa. The patient died several hours after operation. At necropsy, a suppurative meningitis involving the region of the cerebral hemispheres and the cerebral base, also hemorrhages in the region of the right temporal and parietal lobes and of the adjacent cerebellum were found. Histologic examination of the petrous portion of the temporal bone indicated inflammatory processes and an abscess in the internal auditory meatus. There was a considerable destruction of the labyrinth; the resulting cavity was filled with a newly formed connective and bone tissue. The suppurative otitis media brought about necrosis of the labyrinth and an abscess in the internal auditory meatus; the necrotic parts of the bone were gradually absorbed; later the labyrinthine spaces became filled with a granulation tissue, which was transformed further into connective and bone tissue. The labyrinthine spaces proved to be completely filled within three months after the disease started. The newly formed bone was of the periosteal type in which the osteoblasts are involved. While the new bone tissue was found in the cochlea and the semicircular canals, the new connective tissue was found in the vestibule. The abscess of the internal auditory meatus was the probable origin of the meningitis; the prolonged sun radiation may have promoted activation of a latent infection and development of meningitis. The author stresses that in similar cases, the presence of infectious foci ought to be excluded before an intense sun radiation is held responsible for the occurrence of the meningitis.

EDITOR'S ABSTRACT.

PERSISTENCE OF FETAL SEPTUM IN MASTOID PROCESS. J. MÖLLER, Ztschr. f. Hals-, Nasen- u. Ohrenh. **26**:464 (Sept. 20) 1930.

The publications of O. Körner on the clinical importance of the petrosquamous septum awakened Möller's interest, and he examined a series of sixteen temporal bones in order to discover how the cells are distributed in various temporal bones, and to what extent the squamous and the petrous cell systems are separated from each other. From his description of the sixteen temporal bones, it appears that in almost all cases there was a distinct separation between the squamous cells and the petrous cells. In only one case was there no separation. A complete separation, with no communication, was found in seven of the sixteen cases. In one case in which there were two separate cell systems it is possible that both systems developed from the squamous portion, as these cells lead into the external anterior part of the antrum, which is separated from the inner posterior portion by a rather high fillet. In this case the larger portion of the mastoid process has no air cells. In three cases, Möller found in the upper portion a few small openings, through which communication between the two cell systems was established. In five cases, the two cell systems were partially merged together, being separated by only a spongy bone tissue. In three cases, three distinct cell systems were found. In two of these three cases, the third cell system probably belonged to the petrous system; in the third case, more likely to the squamous portion. In view of the fact that Körner was the first to call attention to the surgical importance of these two distinctly separate cell systems, Möller suggests that the petrosquamous septum be termed the "Körner septum."

EDITOR'S ABSTRACT.

Pharynx

ASPIRATION IN TONSILLECTOMY: COMPARATIVE MERITS OF POSTURE AND OTHER FACTORS; A BRONCHOSCOPIC STUDY OF ONE HUNDRED AND TEN PATIENTS. H. J. HARA, California & West. Med. **33**:628 (Sept.) 1930.

In this series are reported the cases of 110 patients, from 3 to 4 years of age, in whom the tonsils and adenoids were removed. The tonsillectomies were per-

formed by the dissection and snare method, and the La Force adenotome was used for the adenoidectomies. Ether was used as the anesthetic, the open cone being used at the beginning of each anesthesia; this was changed to compressed air vaporization just before the operation began, a rubber tube carrying the ether to the angle of the patient's mouth. The factors considered were suction, the operating time, hemorrhage, cough, vomiting and posture.

The author concludes: 1. Bronchoscopic study immediately following operation seems to offer one of the best methods of estimating the amount of inspired blood and secretions present after tonsillectomy. 2. The Rose position affords the greatest protection against aspiration. The next in order are: the Trendelenburg position, extreme extension and moderate extension. The Bostonian posture yields the largest amount of aspiration. 3. Anesthesia should be as light as is compatible with careful surgical manipulation. The deeper the narcosis the greater will be the amount of material aspirated. 4. Suction and dry sponges such as are used during tonsillectomy form a useful armamentarium, but they do not assure absolute protection against aspiration. 5. With a proper combination of the methods mentioned in these studies, the hazards of aspiration may be markedly reduced.

DICKEY, San Francisco.

ROENTGEN TREATMENT OF HYPERTROPHIED TONSILS. L. KLOTZ, München. med. Wchnschr. **77**:1756 (Oct. 10) 1930.

The treatment of hypertrophied tonsils by exposure to roentgen rays passing through the skin may result in areas of erythema and pigmentation. To avoid this possibility, Klotz applies the roentgen rays through the mouth. In this way a smaller field is irradiated and there is less danger of injury to other tissues. The technic is described in detail. Two treatments are given, two or three days apart. Forty patients, five of whom were between 6 and 12 years of age, were satisfactorily treated. A few patients had dryness of the mouth for one or two days. There were no other undesirable effects. In half of the cases the tonsils shrank to normal size in two and a half months. Only when roentgen treatment fails, should surgical removal be considered. BRAHDY, Mount Vernon, N. Y.

CASE OF GOUTY DEPOSITS IN PHARYNGEAL MUCOSA. H. LÖLLKE, Ztschr. f. Hals-, Nasen- u. Ohrenh. **26**:359 (Sept. 20) 1930.

The case described by Löllke occurred in a man, aged 40. At the age of 16, the joint of the right great toe became suddenly swollen and extremely painful. The disease was diagnosed as gout; attacks recurred at short intervals. Four years prior to admission to the hospital, disturbances of swallowing and of speech appeared during the attacks. On examination, tophi were on the fingers, feet and legs up to the knees. There were ulcerations from which a creamy deposit escaped. Three nodes, each the size of a pea, were present in the prepuce; moreover tophi were located on the free auricular margin, on both sides and at the nasal tip. A swelling the size of a walnut was found at the nasal root in the region of the left frontal process. Numerous tophi of various sizes appeared in the mucosa of both anterior palatine arches; two tophi were visible on the right tonsil. In the middle of the tongue, a tophus the size of a millet grain showed through the mucosa. Chalky deposits were situated in the posterior pharyngeal wall up to the hypopharynx. The lingual base, the larynx and the nasopharynx appeared intact. Exploratory excision of the palatine arch, followed by microscopic examination, indicated the presence of crystals of monosodium urate. They penetrated into the tissue of the soft palatine arch. The treatment consisted in administration per os of a low solution of chiniofon and of a preparation containing salicylic acid. The gouty attacks became milder and rarer.

EDITOR'S ABSTRACT.

PATHOGENESIS OF PYEMIA FOLLOWING SORE THROAT, WITH REFERENCE TO TWO CASES. R. WALDAPFEL, Ztschr. f. Hals-, Nasen- u. Ohrenh. **26**:429 (Sept. 20) 1930.

In one of Waldapfel's patients, a man, aged 64, the disease started with a sore throat and a mild fever. On admission, the following was found: A swelling was situated above the right clavicle; it extended from the anterior, middle line of the neck to 2 cm. beneath the mastoid process, posteriorly. The right tonsil appeared slightly enlarged, while the left tonsil remained normal. On intervention, a small amount of pus was found in the swelling; nothing abnormal was seen in the jugular vein. The next day, chills and a septic jaundice developed, followed by death two days later. At necropsy, a phlegmon was detected in the region of the sternocleidomastoideus. Two glandular abscesses were located at the anterior wall of the internal jugular vein; the whole cervical portion of the vein was filled with purulent thrombi. The abscess has ruptured through the venous wall. Streptococci were detected in the pus. The tonsils appeared normal; they were surrounded by a layer of fibrous tissue containing perivascular lymphocytic infiltrates. Numerous infiltrates surrounded the vessels in the parapharyngeal space. Another glandular abscess was found near the carotid bifurcation; like the first abscess, it proved to have penetrated the jugular vein. Two small isolated abscesses were located in the scalenus medius. The second case was observed in a woman, aged 26, in whom the disease started with a sore throat followed the next day by recurring chills. On examination, the left tonsil and palatine arch appeared inflamed and swollen; the glands were enlarged in the left submaxillary region. On pressure, pus escaped from the diseased tonsil. Tonsillectomy was performed; no pus was found elsewhere than in the tonsil. Cultures of blood proved sterile. A dry pleurisy developed on the left side followed by high fever ending in death. At necropsy, the enlarged cervical glands appeared to compress the left jugular vein, whereby one of them proved to have caused thrombosis of the jugular vein. Purulent nodes were situated in the inferior lobes of both lungs; the adjacent pleura was covered with fibrinopurulent membranes. No microscopic examination took place, because the macroscopic lesions were identical with those of the first case. In both cases no bacteria were detected in the involved gland, outside the abscess.

EDITOR'S ABSTRACT.

SORE THROAT. D. HERDERSCHÊE, Nederl. tijdschr. v. geneesk. **74**:5368 (Nov. 1) 1930.

The author discusses the clinical pictures that may exist or arise when complaints about the throat are present at different ages. In infants one must always think of the possible existence of a retropharyngeal abscess. In older children one must consider scarlet fever and diphtheria. In adults syphilis, Plaut-Vincent's angina and the different kinds of angina with a changed white blood cell picture, as well as sepsis following tonsillitis, must be considered. The article contains a number of practical remarks and observations from the rich experience of the author.

VAN CREVELD, Amsterdam, Holland.

PYEMIA FOLLOWING TONSILLECTOMY. A. A. BOONACKER, Nederl. tijdschr. v. geneesk. **74**:5759 (Nov. 22) 1930.

In recent years several cases of pyemic and septic conditions resulting from infections of the tonsils and the peritonsillar tissue have been reported. The author reports a case of tonsillar pyemia following tonsillectomy in a boy, aged 8 years. The adenoids and both tonsils were removed. The indications were repeated tonsillitis and high fever. Nothing significant occurred at operation. The tonsils were rather large. No anesthesia was used. Ten days after the operation high fever with an attack of chills appeared, and at the same time there was otitis media on the left side. The child became seriously ill. Distinct swelling of the cervical lymph glands, especially on the right side, appeared with swelling

of several joints. The attack of chills recurred. *Streptococcus longus* was found in the blood. The right jugular vein was exposed and ligated as low as possible. The distal part of the vein was excised and proved to contain yellow pus. Abscesses of several joints appeared later and were opened. Then a metastatic pneumonia and pleuritis developed. It was more than three months after the operation before the patient was discharged from the hospital as cured. The fact that the otitis media arose at the same time as the first attack of chills speaks against an otogenic pyemia. The strong infiltration of the jugular vein found at operation indicates a tonsillogenic pyemia in this case.

VAN CREVELD, Amsterdam, Holland.

Larynx

CASES OF SPECIFIC INFECTIOUS RHEUMATISM INVOLVING UPPER DIGESTIVE TRACT AND LARYNX. S. YOSHITAKE, Ztschr. f. Hals-, Nasen- u. Ohrenh. **26**:366 (Sept. 20) 1930.

One of Yoshitake's cases was observed in a man, aged 22. Sixteen days before the patient's death, the disease started with fever and pains in the joints, and was diagnosed as acute polyarthritis. A large rheumatic infiltrate was found on the left tonsillar capsule; it penetrated into the muscular tissue. An analogous, but more recent, infiltrate was located on the right tonsil; this tonsil was secondarily infected. On examination, made sixteen days after the onset of the disease, rheumatic nodules were found in the tongue, esophagus, epiglottis and especially in the posterior pharyngeal wall. The nodules were of the Aschoff type. There was evidence that the rheumatic virus had spread from the tonsils to the upper digestive tract. The second case occurred in a girl, aged 8, who suffered with a cardiac disturbance for three years. At necropsy, numerous nodules were found in the heart; a few nodules were located in the intercostal muscles. Insignificant lesions of rheumatic origin were found in the tonsils; numerous rheumatic nodules were located in the posterior pharyngeal wall, in the upper third of the esophagus and in the tongue. The nodules were mostly situated in the submucosal tissue. Moreover, nodules were present in the laryngeal submucosa and in the periesophageal tissue. Microscopic examination indicated that the nodules were of the tendinous type. The history of a third patient, a woman, aged 38, included articular rheumatism at the age of 12, complicated by cardiac disturbances. At necropsy, typical rheumatic nodules were found in the myocardium, pericardium, in the remaining tonsil, the posterior pharyngeal wall, left piriform recess and esophagus. A few nodules were found in the larynx. There were no nodules in the joints of the legs. The fourth case refers to a man, aged 64, who suffered with an articular disease during the last seven years. At necropsy, lesions of a nodose rheumatism were found. Large nodes were present in the joints, also in the pericardium and in the aorta. Microscopic examination confirmed the rheumatic character of the lesions. Cicatricial formations were present in the tonsils, the pharynx and the larynx. In the four cases of specific, infectious rheumatism, the upper portion of the digestive tract and the larynx proved to be intensely involved. The infection started in the tonsils or in the pharynx and thence spread through contact. When the larynx was infected, the joints proved to be more frequently involved than the tendons or the muscles; evidently a specific, infectious rheumatism, with the primary focus in the tonsils, may be followed by involvement of the larynx exclusively.

EDITOR'S ABSTRACT.

Nose

FAMILIAL (HEREDITARY) EPISTAXIS. H. I. GOLDSTEIN and H. Z. GOLDSTEIN, M. Times, New York **58**:331 (Nov.) 1930.

The authors review the literature and report three groups of familial epistaxis. The blood platelets, and bleeding and clotting time are usually normal, which helps

to distinguish this condition from other disturbances of the blood. Little can be done toward a permanent cure; local bleeding may be stopped by astringents, cautery, carbon dioxide snow or radium. Calcium, parathyroid extract-Collip and viosterol have been given internally, and ultraviolet and roentgen rays have been used, with varying results.

SANFORD, Chicago.

PHYSICAL THERAPY MEASURES IN SELECTED CASES OF SINUSITIS. LOUIS FELDMAN, Brit. J. Actinotherapy **5**:184 (Dec.) 1930.

The technic of treatment and the results obtained in 200 cases of sinusitis are reported. There were 100 acute, 71 subacute, and 25 chronic cases. Some of them were observed for three years. The treatment consisted of the application of nasal pledgets of 4 per cent solutions of cocaine and epinephrine for five minutes. This was followed by the application of the indirect high frequency monopolar current from the Telsa or Oudin terminals of a high frequency generator. This was applied for about ten minutes over the sinuses and produced an active hyperemia. In many cases the patient felt a marked improvement as was evidenced by relief from headache and pain and by a more or less mucopurulent discharge. This was followed by the intranasal, intra-oral and pharyngeal application of ultraviolet rays by means of special quartz applicators attached to a water-cooled quartz mercury generator. The treatment was repeated at intervals of from three to five days.

The chronic cases showed only a slight or temporary relief from the treatment, and many patients had recurrences. In the subacute group, thirty-five patients had definite relief for periods of from two weeks to two years. Nearly all of the acute cases showed relief or cure.

In conclusion, the author states that the results warrant further research on this and similar physical measures.

HARTMAN, Cleveland.

ENORMOUS MUCOCELE OF THE FRONTAL SINUS WITH EXOPHTHALMOS AND HYPEROSTOSIS OF THE ORBITAL BONE. V. VIALEIX, BEYNES and THOUVENET, Ann. d'ocul. **167**:177 (Feb.) 1930.

A mucocele of the frontal sinus started when the child was 8 years of age. The condition developed so slowly that there were no muscular anomalies and no injury to the optic nerve.

BERENS, New York.

Miscellaneous

RHINOSPORIDIUM SEEBERI: PATHOLOGICAL HISTOLOGY AND REPORT OF THE THIRD CASE FROM THE UNITED STATES. CARL VERNON WELLER and A. D. RIKER, Am. J. Path. **6**:721 (Nov.) 1930.

After a brief review of the previously reported forty cases, a case of infestation with *Rhinosporidium seeberi* in a man, aged 26, is given. A complete pathologic description and excellent photomicrographs accompany the report. A collection of all cases reveals that the disease has occurred in India, Ceylon, Argentina and the United States and is restricted to the male sex between the ages of 10 and 60. The polypoid masses may occur in the nose, nasopharynx, aural canal, conjunctiva, lacrimal sac, uvula and penis. The mode of infection is unknown, and experimental reproduction in animals has failed. Clinically, the masses appear as polypoid or papillomatous inflammatory new growths which tend to recur. The treatment of choice is complete removal.

MOORE, Cleveland.

A CASE OF OTOGENOUS TOTAL OPHTHALMOPLEGIA (CONTRALATERAL). S. ROSENBLATT, Rev. d'oto-neuro-opht. **8**:523 (July) 1930.

A girl, aged 16, complained of violent headaches, pain in the neck on turning the head, repeated vomiting, chills and fever, and pain in the left ear, which had

discharged since infancy. Examination revealed a poorly nourished girl, apparently suffering greatly, with subicteric color of the skin and sclera. The temperature was 40.2 C. (104.3 F.); the pulse rate was 120; the heart and lungs were normal; pressure over the left mastoid and the sternoclavicular muscle was painful. The left ear was filled with fetid pus; the membrane of the drum was destroyed, and the tympanum was filled with granulations. Hearing in the left ear was greatly reduced. The cranial nerves showed no disturbances. The right patellar reflex was slightly exaggerated. Examination of the blood showed: leukocytes, 16,875; no eosinophils; segmented cells, 62.5 per cent; lymphocytes, 9 per cent, and monocytes, 9 per cent.

A radical operation on the mastoid, performed the next day, revealed a fistula in the bone, filled with pus and granulations, which proceeded from an abscess in the sigmoid sinus to the surface of the bone; the middle ear was filled with granulations and cholesteatoma, and the tegmen of the antrum and tympanum was softened and removed. The infected thrombus in the jugular bulb necessitated extensive resection of the bone and ligation of the jugular vein. A second operation, one week later, uncovered a collection of pus around the jugular bulb and softened bone around the lateral sinus. Improvement followed for a week and then vomiting, diplopia and pain in the right eye and temple appeared, accompanied by an increase of leukocytes in the blood. The pains in the eye continued for a week. The ophthalmoplegia began with the abducens and the levator of the lid, and progressed until there was complete paralysis of all of the ocular muscles, including the pupil. This condition persisted for about one month, when improvement began which progressed until complete restitution of the function of the eye was attained—a period of seventy-five days. At the time of the appearance of the paralysis of the abducens muscle Babinski and Gordon signs were present on the right. The Wassermann reaction of the blood was negative.

The phenomenon of an ophthalmoplegia on the right side resulting from an otogenous infection on the left is explained by the transference of the infection by means of the blood vessels: from the left jugular bulb through the left inferior petrosal sinus, basilar plexus and the right petrosal sinus to the point at which the latter joins the cavernous sinus. This produces edema in the basal meninges and perhaps a circumscribed meningitis also at the point of the petrous pyramid, at which the oculomotor nerves and the gasserian ganglion are close together, and results in a neuritis of these structures. The assumption is that the virus is much attenuated.

DENNIS, Colorado Springs, Colo.

DISTURBANCES OF HANDWRITING IN SUBJECTS WITH ADENOID VEGETATIONS. D. J. VASILU, Rev. d'oto-neuro-opht. **8**:531 (July) 1930.

Agraphia is a symptom of different forms of motor or sensory aphasia and is found in other nervous diseases: multiple sclerosis, jacksonian epilepsy, dementia paralytica, etc. After discussing the mechanics and pathologic physiology of aphasia and agraphia, the author attempts to explain the disturbances in the handwriting, or partial agraphia, observed by him in school children with adenoids. In these children the writing is irregular, the letters are unequal, certain letters, syllables or even words are missing, the lines are not straight, and the copy is marred by blots due to inattention. All of these faults are improved or eliminated after removal of the adenoids. When the adenoid becomes markedly hypertrophied it produces a hormone which sets up psychonervous disturbances, characterized by starting up during sleep, incontinence of urine, irascibility, etc. These same hormones may also produce excitation of a slight degree in either the graphic centers or in the coordinating cortical cells and thus produce partial agraphia. Another explanation is that these hormones may produce a vasoconstriction in the cerebral cortex in consequence of excitation of the cervical sympathetic, causing anemia of this area or of the graphic centers, which causes "amnesia in the handwriting," analogous to amnesia in spoken language.

DENNIS, Colorado Springs, Colo.

Society Transactions

MASSACHUSETTS EYE AND EAR INFIRMARY, OTO-RHINO-LARYNGOLOGICAL SERVICES

EDITED BY PHILIP E. MELTZER, M.D.

Regular Clinical Meeting, Oct. 22, 1930

SECONDARY TOTI-MOSHER OPERATION. Presented by DR. LEROY SCHALL.

In the last service I operated on a woman who had two abscesses of the lacrimal sac. The sac was found to be a mass of scar tissue, so I had great difficulty in separating it from the normal tissues. The puncta lacrimalia was very small. Dr. Chandler succeeded in dilating it, but could not get a probe into the nose. Lacrimation continued. Two weeks before presentation, I reoperated and found the bony opening into the nose to be sufficiently large. There was a little tract of scar tissue, and fortunately I put my probe into this scar tissue and dilated the canal as large as I dared. I think I used a no. 4 dilator. However, the patient is still suffering from lacrimation. The question is what is the future treatment? Shall we use the metal stylet, or extirpate the lacrimal gland?

DISCUSSION

DR. L. HAPP: At present I can get a no. 6 bougie through the punctum into the nose, but there is still lacrimation.

DR. C. T. PORTER: I have one of those cases in which the common punctum is bound down with scar tissue, even after the patient wore a stylet for from six to eight months. Most patients wear them one or two months and get along fairly well. In this case, I think I would employ a stylet immediately. If the punctum has been split, as was the case in many of the patients we first saw, there is always considerable lacrimation.

DR. LEROY SCHALL: The punctum was not split.

DR. C. T. PORTER: Possibly it will be all right if a stylet is used; the inner punctum will reform.

PERICHONDRITIS OF THE LARYNX. Reported by DR. E. W. HERMAN.

A fireman, who gave a history of injury to his spine from falling off a ladder, has been under observation for some time for edema and swelling of his larynx; the condition did not progress as though it were malignant, but instead gradually improved. It is quite possible that the larynx may have been injured at the time of the fall. It was necessary to employ tracheotomy for an edematous mass in the larynx. The patient is decidedly better now. The roentgenogram is interesting, as it shows a marked loss of laryngeal cartilage. Ordinarily quite a bit of calcification can be seen in the box of the larynx. Instead of an increased area of density, there is a rarefaction as though cartilages had been destroyed, following an inflammatory infiltration, with subsequent perichondritis and an abscess of the cartilaginous tissue. I am presenting this case because of the unusual x-ray picture of the larynx.

DISCUSSION

DR. A. S. MACMILLAN, roentgenologist: The roentgenogram of this larynx shows a laryngeal swelling in the region where the thyroid cartilage should be, and a swelling in front of the trachea. There is no swelling in front of the esophagus, but details of the cartilage are entirely lost, and there is marked swelling of the arytenoids.

EDEMA OF THE GLOTTIS. Presented by DR. E. W. HERMAN.

A patient came in yesterday suffering from extreme dyspnea. I saw her in Gardner ward as an emergency patient. She had a temperature of 104 F. According to the history she had had a sore throat for about one week with gradual increase in dyspnea. Yesterday morning when she came in she was struggling for breath, inspiratory in type. A tracheotomy was done, and for the time being she seemed comfortable. The trachea was displaced somewhat to the left, but no definite deep abscess could be palpated. The tissues were rather porky. Rectal feeding was instituted, cold packs were put on her neck, the tracheotomy tube was changed as necessary and morphine was given. A few hours later more dyspnea developed, and Dr. Boies and Dr. Wright checked up on the drainage by passing a no. 5 bronchoscope into the bronchi. No obstruction was seen, yet the patient had spasms of respiratory difficulty. Following bronchoscopy, she again breathed comfortably. I do not know what happened the latter part of the afternoon, but she died about 10 p. m., with a picture of an overwhelming septic process. The bronchoscope was passed in the afternoon because the medical attendants said that no air was entering the lung. With the aid of the bronchoscope, Dr. Boies saw a membrane in the region of the laryngopharynx.

DISCUSSION

DR. L. BOIES: I could not see into the laryngeal lumen at all.

DR. E. W. HERMAN: A culture was taken showing a virulent hemolytic streptococcus. Her white count was 1,000 as in an agranulocytic case. The dyspnea was startling at the time. She was given diphtheria antitoxin on general principles. As there was a history of distress on breathing, I wanted to make sure that this possibility was not overlooked.

DR. L. BOIES: This patient apparently was getting air through the tube. She was cyanotic. I believe that she died from cardiac failure. I could not take her blood pressure; the pulse was not palpable.

FRACTURE OF THE BASE OF THE SKULL. Presented by DR. J. E. QUINCY.

About three months ago the patient was struck on the right temporal region with a heavy iron beam. He was in the hospital two weeks. There was a history of bleeding from the middle ear, and he recovered fairly well except that he still had headache. The first x-ray plates I saw were made here, and they were negative. Another plate made by a different man showed a definite fracture through the petrous portion of the temporal bone. Will Dr. MacMillan kindly explain the angle at which the roentgenogram was taken? This is a case of accidental injury, and it is important to establish a roentgen diagnosis for the possibility of potential fracture.

DISCUSSION

DR. A. S. MACMILLAN, roentgenologist: I did not get in the angle of the fracture. In cases of fracture, one should take two or three angles. The fracture runs right through the external auditory meatus toward the squamous portion.

FOREIGN BODY IN THE LUNG. Presented by DR. D. C. SMYTH.

A baby, aged 21 months, developed a cough shortly after eating a lollipop. Roentgen examination showed a foreign body, which I did not recognize. It was in the left bronchus and caused obstructive emphysema. When removed, it was black and evidently metallic. In removing it, I took hold of it by direct vision and then moved the patient downward holding the foreign body with the forceps, and having Dr. MacMillan confirm the fact that I was moving it, then delivered it through the glottis under fluoroscopic control. It proved to be a piece of a metallic toy.

BILATERAL MASTOIDITIS WITH SINUS THROMBOSIS. Presented by DR. H. P. CAHILL.

A simple mastoidectomy was performed on a child, aged 4 years, at Dover, N. H. He was seen in consultation with a surgeon from Boston who reoperated on the mastoid. The patient was brought back to Boston and finally brought to the Eye and Ear Infirmary with a temperature of 105 F. On roentgen examination we found that the other mastoid was well broken down. That was cleaned out, and the sinus was exposed, also the sinus of the mastoid on which operation had previously been done. A Tobey-Ayer test at that time was negative. The white blood count was 14,000. The second day it was 12,000, but the temperature was still of the picket fence type. The third day a Tobey-Ayer test showed a positive reaction in the left jugular vein. I tied the left jugular vein at the level of the facial vein and also tied off the facial vein. I opened the sinus and found it filled with pus. The patient was given a transfusion. I want to say a word about the Tobey-Ayer test. I do feel that one ought to start the pressure equally on both sides, then take it off one side and then press both, and then take it off the opposite side, and so on in order to have a fair test.

LABYRINTHITIS WITH FACIAL PARALYSIS. Presented by DR. H. P. CAHILL.

A patient with a chronic condition of the ear, facial paralysis, a dead labyrinth and bilateral nystagmus was admitted to this service. On account of the bilateral nystagmus, we simply did a radical mastoidectomy. The condition is clearing up. The question comes up whether we should have done a labyrinthectomy or just a radical mastoidectomy. We could not get a good labyrinth test because of the amount of granulations in the ear, and secondly because of the presence of a bilateral nystagmus. There were no cerebellar signs or symptoms. The facial nerve was found exposed about one-half inch just below the horizontal canal. It will be interesting to follow the patient to see if he turns out to have a cerebellar abscess with no symptoms, that is, none at the onset. The other cases shown proved later to be cerebellar abscesses, without signs at operation.

CARCINOMA (SLIDES). Presented by DR. ANGUS MCLEOD.

The specimen is from a case of carcinoma in a woman 53 years of age. Two months ago she complained of soreness on swallowing. A section showed epidermoid carcinoma, type II, not growing very rapidly.

DISCUSSION

DR. E. W. HERMAN: That patient had some roentgen treatments for four days before the specimen was removed. Did it show any effect of the radiation?

DR. ANGUS MCLEOD: There was no evidence of fibrosis. There are not a great many mitotic figures present. The cells are well differentiated.

Regular Clinical Meeting, Nov. 26, 1930

CYST OF THE ANTRUMS. Presented by DR. R. L. GOODALE.

The patient was referred by Dr. Walker with the following history: Two years before she was seen by Dr. Goodale she had an abscessed tooth on the right side with severe swelling and pain in the region of the right antrum; the abscess finally broke through the right upper gum, which brought relief. Ever since then there had been some nontender swelling in the right canine fossa. Six weeks before, the swelling increased; the abscess was opened, and relief obtained. Since then pus had been appearing in the right upper gum. The question was whether the tooth removed two years before was the cause of the trouble. A roentgenogram showed cysts of the antrums and a retained root on the left side; probably there was a

partial extraction and a piece of tooth was still there. A bilateral radical operation on the antrum was done, and on the right side the cyst had caused the anterior wall to become so thin that it was practically decalcified. On opening it, I found some thin purulent watery material, and on the floor of the antrum there was a great deal of scar tissue. The naso-antral wall was thinned out until it was nothing more than a soft almost paper-like mucous membrane. Posteriorly, the wall was also soft, and I did not like to work back that way. I made large openings under the inferior turbinate. There was a large cyst on the left side, and on removing it, a fragment of the root of the tooth came with it. An opening was made in the inferior meatus. Since then, swelling had developed on the right side, and the opening in the canine fossa on that side had not completely closed after one week. The opening on the other side was completely closed. The condition was evidently a cyst of both antrums of dental origin.

DISCUSSION

DR. H. P. MOSHER: How would you close the flaps of the mucous membrane of the canine fossa?

DR. R. L. GOODALE: I do not close them. I put in a pack. I do not think there is any objection to closing except that later bleeding may start.

DR. D. C. SMYTH: I close the opening in the canine fossa following a radical operation on the antrum. Some operators follow this procedure and some do not. The only fistula that ever resulted in my cases following a radical operation on the antrum occurred when I did not sew the opening.

DR. H. P. MOSHER: I always use two sutures. As for packs, one can always get the packing out through the nose with a pair of forceps.

DR. D. C. SMYTH: But a hemorrhage following a radical operation on the antrum is rare, except at the posterior margin of the opening of the naso-antral wall.

DR. H. P. MOSHER: How many men in the clinic pack the antrum after a radical operation, using a light petrolatum gauze?

DR. D. C. SMYTH: Three do and ten do not. I prefer using a piece of rubber dam with gauze. I think that petrolatum gauze starts bleeding.

DR. C. T. PORTER: I leave the pack in twenty-four hours in a severely infected antrum. I take it out through the nose.

DR. R. L. GOODALE: May I ask what the great advantage is in putting in a pack for the first twenty-four hours?

DR. H. P. MOSHER: With the pack one can obtain a large jelly-like clot in the antrum, which becomes septic.

DR. D. C. SMYTH: I should like to know how many men here do not treat the antrum postoperatively. By the hands that are raised, I see that pretty nearly all do.

ORBITAL ABSCESS. Presented by DR. PHILIP MYSEL.

A boy, aged 6, came into the outpatient department of the throat service on November 15. On November 10, a swelling appeared above and on the lateral aspect of his eye. He had pain for two weeks and a cold in the head for one week. He was seen by Dr. Shambaugh, Jr., who advised that roentgenograms be made of the sinuses, and referred him to the optical department for examination. He was admitted to the optical service on the same day, where an examination showed a blurred disk. The conjunctiva in the lateral aspect of the eye was inflamed; the movements of the eye were normal. Results of the endonasal examination were negative. The child was observed in the optical service for five days. During this time his condition evidently became worse. Dr. Herman saw him in consultation on November 15. The lids were edematous and discolored. There was pro-

nounced exophthalmos. Dr. Herman felt that the orbit should be explored, and if any opening was found through the sinus that nasal drainage should be established. His general condition was good at all times. The temperature had never risen above 100 F. The question was whether the symptoms were a toxic or a metastatic manifestation. I explored the orbit through the Killian incision, and it was found to be normal with no signs of infection. The bony wall of the ethmoid was intact. I inserted a rubber dam drain, and closed two thirds of the wound. Roentgenograms of the sinuses showed slight thickening of the antrum and ethmoid. A roentgenogram of the chest showed considerable thickening of the hilus on both sides, consistent with tuberculosis. The patient was watched for five days; if there was any change, his eye looked worse than before. On the fifth day the pus began to discharge into the conjunctiva on the lateral aspect. This pus cavity was opened, and after that the eye improved remarkably.

DISCUSSION

DR. D. C. SMYTH: Where did they find the pus?

DR. PHILIP MYSEL: The pus was found coming through Tenon's capsule above and below the insertion of the external rectus muscle.

DR. D. C. SMYTH: Why did you not explore the orbit before the pus broke through?

DR. PHILIP MYSEL: At the time of operation, I palpated the retrobulbar region through the orbit and did not find any induration; I thought it better to watch the patient than to explore for such a complication.

DR. C. T. PORTER: What is the history of the onset?

DR. PHILIP MYSEL: The patient had a cold for one week. Eight days before he came into the hospital, a carbuncle on his chest had been incised. I wonder if tuberculosis plays a rôle in metastatic infection.

DR. C. T. PORTER: As to Dr. Mysel's last statement, roentgen examination of children at this time of the year is frequently suggestive of tuberculosis of both the thymus and the chest. We find that in from six to eight of ten cases the roentgenograms suggest tuberculosis. Those patients have been followed carefully medically, and tuberculin tests have been made, but so far there has been no evidence of active tuberculosis in from three weeks to a month. These patients have also been anesthetized, and have reacted like other patients. A pediatrician told me that roentgen evidence suggestive of tuberculosis is quite common in children after colds during the winter months. The majority of the children show such roentgen signs, but there is no clinical proof that the disease is present. Now as to the real disease for which this child is being presented; to me he presents a very definite history. Granting that there are metastatic abscesses, I should say that from 90 to 95 per cent of the orbital abscesses are of nasal origin, that is, they develop in one of two ways. An actual abscess may develop in the ethmoid, and all the partitions break down. Then there is direct extension through the ethmoidal cells and periosteum into the orbit. In the nose, nothing is seen but a boggy turbinate or perhaps some pus. In other words, there is an abscess in the ethmoid breaking through into the orbit. Another type of case is that following an acute dry rhinitis; later, swelling and edema of the lids and conjunctiva develops, and still later, if the infection continues to extend through the orbit, there is marked exophthalmos with limitation of motion; finally there is visual disturbance, but this does not happen often. There is thrombosis of a vein, which later breaks down into the orbit, and an abscess forms. I think it could extend through the lymphatics as well. In the meantime, the condition in the nose subsides, but the infection progresses to the formation of an abscess in the orbit. I believe that this boy had an orbital abscess secondary to an infection in the antrum and ethmoid without evidence of pus in the nose.

DR. H. P. MOSHER: What more would you have done in the way of operative procedure?

DR. C. T. PORTER: I certainly would have explored the ethmoid and antrum. I think one has to decide each case on its own merits.

DR. H. P. MOSHER: Do you think that all cases represent infection from the ethmoid?

DR. C. T. PORTER: Yes, practically so.

DR. PHILIP MYSEL: When the swelling started it was on the lateral aspect of the eye; if the infection came from the ethmoid, the pathologic process would be on the medial rather than on the lateral aspect; that is, there would be thrombosis of the veins and periosteal thickening.

DR. C. T. PORTER: I think the periosteal thickening that results depends on how much retraction there is. I do not think that thrombosis of the veins necessarily causes periosteal thickening. The orbit, unless quite tender to palpation, gives no evidence of what is going on there. If the thrombosis breaks down, it might as well do so at a distance from the point of entrance as near it. If there is direct extension from the ethmoid, a reaction occurs first in the region of the upper canthus and the upper lid rather than the lower lid.

DR. H. P. MOSHER: It is rather unsual to find pus laterally, at least such has been my experience. Usually it is in the upper or the lower lid.

DR. PHILIP MYSEL: The right medial wall of the orbit was entirely normal.

DR. H. P. MOSHER: But you did not explore through Tenon's capsule. It is almost humanly impossible to tell where the pus is in the orbit.

DR. E. W. HERMAN: In this particular case the tissues were clean and healthy looking all along the ethmoidal wall. The first roentgenograms were entirely negative, and the history of a cold was not marked. Nevertheless, the feeling we all had made it justifiable to explore by the external route.

DR. H. P. MOSHER: How many abscesses were not opened and not followed by exenteration of the ethmoid?

DR. E. W. HERMAN: I remember only three.

DR. H. P. CAHILL: Did not this child's antrum show some clouding in the roentgenogram?

DR. A. S. MACMILLAN: The antrum was clear. A roentgenogram taken later showed slight thickening. There was an inflammatory reaction in the vicinity at the time of operation.

DR. PHILIP MYSEL: The first roentgenogram was taken one week after the cold had subsided.

DR. H. P. MOSHER: I believe that it has been a great advance to consider all cases of orbital abscess, especially in the adult, as originating in the ethmoid, and I feel that simply evacuating the pus has been the routine procedure. I think it has been the routine procedure in the ophthalmologic service.

DR. D. C. SMYTH: It is only within the last three or four years that ophthalmologists, at least here, have acknowledged that orbital abscess and suppuration of the orbit are directly related to the ethmoid.

DR. H. P. CAHILL: We see many children with edema of the lids occurring with acute nonsuppurative rhinitis; then it disappears. Do you not think those cases are like the ones described by Dr. Porter in which suppuration did not develop?

RECURRENT ESOPHAGEAL POUCH. Presented by DR. E. W. HERMAN.

This case is a disappointment to me, and I am greatly puzzled as to what to do. The patient has an esophageal pouch of about ten years' duration which was operated on in the beginning of this service. A two-stage operation was done, and before the patient left, Dr. MacMillan performed a fluoroscopy and found that the patient was swallowing without difficulty or without any evidence of constriction. We thought the result was most satisfactory. The patient came

back two months later with a little difficulty in swallowing and a pouch forming. I examined him by means of the esophagoscope to see if there was any stricture to cause the pouch to form, and the picture was different from any I have seen. It looked as though both piriform sinuses had opened into a large bag. In front of the pouch, there appeared to be a regular esophageal opening. The sphincter appeared with regular strands of mucous membrane. I could slip a bougie in without difficulty. The appearance was a little misleading on looking down. It seemed like a greatly enlarged piriform sinus. The esophageal opening was almost in the midline in front. The whole posterior wall was flabby and relaxed. Of course, the patient is not having great difficulty now; he can swallow everything.

DISCUSSION

DR. H. P. MOSHER: How well did the pouch empty? Did it spill over?

DR. A. S. MACMILLAN: It emptied in about five minutes. It did appear to be a pouch with a regular neck. It did not spill over.

DR. H. P. MOSHER: This man does not seem to have marked symptoms. I feel that enough of the pouch was not taken out. The sac was not brought to the surface of the skin. I think we ought to improve our technic and to work with Dr. Lahey before operating in other cases. It is going to be rather hard to get the rest of the pouch out now. I should temporize, and if the patient can be taught to pass a bougie himself, I should have him do it. If this does not help, I recommend reoperation by the Lahey method.

DR. WALTER B. HOOVER, Lahey Clinic: I think that there is something about these pouches that is not fully understood. Every now and then we see a person who cannot swallow, and on esophagoscopy the opening seems to be in the posterior cricoid region rather than at the bottom. If the upper end of the esophagus is dilated, many of these patients will swallow without difficulty for a long time. I think this is perhaps a condition that presents esophageal abnormality. After an operation is done on a pouch, I think it worth while to dilate the upper end of the esophagus for some time to relieve any spasm or constriction; at least, when one can see directly with a laryngoscope or suspension apparatus. I would suggest dilating this man's pouch by means of a string or directly. Dilation of the upper end of the esophagus may prevent recurrence.

DR. H. P. MOSHER: As to spasm around the upper end of the esophagus, I think I proved fairly satisfactorily that in the majority of cases in which these pouches occur the asymmetry of the piriform sinuses is due to some type of inflammatory reaction.

SLIDES PRESENTED BY DR. H. P. MOSHER.

The slide showed a section of the esophagus of a scrobutic guinea-pig which shows a marked amount of hyalinization. I find that the normal guinea-pig has a marked amount. I have to obtain a guinea-pig not related to this one in order to find out whether this observation holds true. The hyalinization extends well down in the epithelium.

HUNT'S DISEASE. Presented by DR. BOIES.

A woman, aged 26, was sent to the emergency ward with a letter stating that she had had considerable pain in the right ear followed by facial paralysis. On examination, the drum membrane appeared normal although a little opaque along the handle of the malleus; she gave a normal reaction to tests for hearing. The roentgenogram was normal. The patient had a cold one week before admission, but she had constantly improved. The morning before admission, she awakened with facial paralysis and dizziness, and staggered on getting out of bed. She vomited once. There are no vestibular symptoms at present. Neurologic examination gave negative results. She had deficiency in taste in the anterior two thirds of

the tongue. In Hunt's disease, there is involvement of the geniculate ganglion, with herpes and pain in the ear. This patient did not have herpes, however. She had rotary nystagmus to the good ear.

DISCUSSION

DR. H. P. MOSHER: How does Hunt's disease differ from Bell's palsy of long standing with an associated infection?

DR. LAWRENCE BOIES: It is quite different except for the pain. The nystagmus is explained by involvement of the vestibular ganglion. The patient had some tinnitus this morning. She had referred pain to the teeth.

DR. HAROLD TOBEY: Has she any pain in the auricle?

DR. LAWRENCE BOIES: She has pain in the ear.

DR. H. P. MOSHER: Do you think that there was any infection of the middle ear?

DR. LAWRENCE BOIES: The drum looked a little thickened and slightly reddened along the handle of the malleus. The ear was opened, but was dry.

DR. C. T. PORTER: I saw one case of definite herpes six or eight years ago. I have seen one since. Blebs developed in both cases. In the first case the canal was very red, but there was no bulging or thickening. There was a certain amount of irritation that the patient described as itching. Later, definite blebs appeared in the medial portion of the canal and drum. I did not operate, and facial paralysis did not develop.

DR. LAWRENCE BOIES: The geniculate is sensory.

DR. PHILIP MYSEL: In 1897, Frankel-Hockwart described a symptom-complex which he called polyneuritis cerebralis menieriformis, a neuritis of the nerves associated with the temporal bone; namely, the fifth, seventh and eighth nerves. The involvement of the nerves causes the following symptoms: pain and herpes, fifth nerve; facial paralysis, seventh nerve; nausea, vomiting, disturbances of equilibrium and nystagmus, vestibular branch of the eighth nerve; noises, loss of hearing and deafness, cochlear branch of the eighth nerve. The middle ear is normal, and a herpetic blister may develop on the drum. The symptoms and signs will depend on the nerves involved and the degree of inflammation. Any combination of symptoms may be present. Characteristic of the disease is the limping fashion in which the nerves are affected, first one and then the other. When they recover, they do so in the same manner, first one and then the other. The prognosis to life is good. However, if the neuritis is severe, one or more nerves may remain permanently paralyzed. Following the epidemic of infantile paralysis on the continent in 1908 and 1912, a number of these cases appeared. Some of the European observers feel that there is a close relationship between this syndrome and anterior poliomyelitis.

Directory of Otolaryngologic Societies *

NATIONAL

American Medical Association, Section on Laryngology, Otology and Rhinology

Chairman: Dr. T. E. Carmody, 227, 16th St., Denver.
Secretary: Dr. Gabriel Tucker, Bronchoscopic Clinic, University Hospital, Philadelphia.
Place: Philadelphia. Time: June 8-12, 1931.

American Academy of Ophthalmology and Oto-Laryngology

President: Dr. William H. Wilder, 122 S. Michigan Ave., Chicago.
President-Elect: Dr. J. F. Barnhill, Miami Beach, Fla.
Executive Secretary: Dr. William P. Wherry, Medical Arts Bldg., Omaha.
Place: French Lick, Indiana. Time: Sept. 14-19, 1931.

American Bronchoscopic Society

President: Dr. Henry B. Orton, 24 Commerce St., Newark, N. J.
Secretary-Treasurer: Dr. Louis H. Clerf, 128 S. 10th St., Philadelphia.
Place: St. Louis. Time: June 6, 1931.

American Laryngological Association

President: Dr. Francis R. Packard, 304 S. 19th St., Philadelphia.
Secretary: Dr. George M. Coates, 1721 Pine St., Philadelphia.
Place: Atlantic City, N. J. Time: June 15-17, 1931.

American Laryngological, Rhinological and Otological Society

President: Dr. Max A. Goldstein, 3858 Westminster Pl., St. Louis.
Secretary: Dr. R. L. Loughran, 33 E. 63d St., New York.
Place: St. Louis. Time: June 3-5, 1931.

American Otological Society

President: Dr. David H. Walker, 101 Bay State Rd., Boston.
Secretary: Dr. Thomas J. Harris, 104 E. 40th St., New York.
Place: Briarcliff, N. Y. Time: June 17-19, 1931.

SECTIONAL

Eastern New York Eye, Ear, Nose and Throat Association

President: Dr. G. G. Marshall, 122 West St., Rutland, Vt.
Secretary-Treasurer: Dr. Arthur F. Holding, 142 Washington Ave., Albany.
Time: Third Wednesday of October, November, March, April, May and June.

New England Otological and Laryngological Society

President: Dr. Harry P. Cahill, 520 Commonwealth Ave., Boston.
Secretary-Treasurer: Dr. Lyman G. Richards, 319 Longwood Ave., Boston.

Pacific Coast Oto-Ophthalmological Society

President: Dr. Chester H. Bowers, 1136 W. 6th St., Los Angeles.
Secretary-Treasurer: Dr. Walter F. Hoffman, 817 Summit Ave., Seattle.

Puget Sound Academy of Ophthalmology and Oto-Laryngology

President: Dr. Albert E. Hillis, 1115 Pacific Ave., Tacoma, Wash.
Secretary-Treasurer: Dr. Francis A. Brugman, 806 Cobb Bldg., Seattle.
Time: 8 p. m., third Tuesday of each month, except July and August.

* Secretaries of societies are requested to furnished the information necessary to make this list complete and to keep it up to date.

SIOUX VALLEY EYE AND EAR ACADEMY

President: Dr. Claude T. Uren, City National Bank Bldg., Omaha.
Secretary-Treasurer: Dr. Frederick H. Roost, 420 Trimble Bldg., Sioux City, Iowa.
Place: Fontanelle Hotel, Omaha. Time: November, 1931.

SOUTHERN MEDICAL ASSOCIATION, SECTION ON EYE, EAR, NOSE AND THROAT

Chairman: Dr. Fletcher D. Woodward, Box 162, University, Va.
Secretary: Dr. W. D. Gill, 323 Medical Arts Bldg., San Antonio, Texas.
Place: New Orleans. Time: November, 1931.

SOUTHWESTERN MICHIGAN TRIOLOGICAL SOCIETY

President: Dr. Wilfrid Haughey, 65 W. Michigan Ave., Battle Creek.
Secretary: Dr. R. H. Fraser, Battle Creek Sanitarium, Battle Creek.
Time: Third Thursday of alternate months.

STATE

COLORADO OTO-LARYNGOLOGICAL SOCIETY

President: Dr. C. E. Cooper, 227, 16th St., Denver.
Secretary: Dr. Rex L. Murphy, Metropolitan Bldg., Denver.
Place: Assembly Room of Metropolitan Bldg. Time: First Saturday of each month from October to May.

CONNECTICUT STATE MEDICAL SOCIETY, SECTION ON EYE, EAR, NOSE AND THROAT

President: Dr. Dorland Smith, 836 Myrtle Ave., Bridgeport.
Secretary-Treasurer: Dr. Walter L. Hogan, 750 Main St., Hartford.

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Secretary: Dr. J. Kent Leasure, 23 E. Ohio St., Indianapolis.

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MONTANA ACADEMY OF OTO-OPHTHALMOLOGY

President: Dr. Lee W. Smith, 125 W. Granite St., Butte.
Secretary: Dr. J. G. Parsons, Lewistown.
Time: Semi-annually.

NORTH DAKOTA ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. H. B. Beeson, 232 W. De Mers Ave., Grand Forks.
Secretary-Treasurer: Dr. F. L. Wicks, Valley City.

OREGON ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. J. W. McCollom, 346½ Washington St., Portland, Ore.
Secretary: Dr. Andrew J. Browning, 418 Mayer Bldg., Portland, Ore.
Place: Good Samaritan Hospital. Time: Third Tuesday of each month.

RHODE ISLAND OPHTHALMOLOGICAL AND OTOLOGICAL SOCIETY

President: Dr. Raymond F. Hacking, 105 Waterman St., Providence.
Secretary: Dr. Herman A. Winkler, 224 Thayer St., Providence.
Place: Rhode Island Medical Library. Time: 8:30 p. m., second Thursday in October, December, February and April.

UTAH OPHTHALMOLOGICAL SOCIETY

President: Dr. F. M. McHugh, 17 Exchange Pl., Salt Lake City.
Secretary-Treasurer: Dr. W. Leroy Smith, Erza Thompson Bldg., Salt Lake City.

VIRGINIA SOCIETY OF OTOLARYNGOLOGY AND OPHTHALMOLOGY

President: Dr. Fletcher D. Woodward, Box 162, University.
Secretary-Treasurer: Dr. Henry Grant Preston, Harrisonburg.
Place: Richmond, Va. Time: May 2, 1931.

WEST VIRGINIA STATE MEDICAL ASSOCIATION, EYE, EAR, NOSE AND THROAT SECTION

President: Dr. S. S. Hall, Fairmont.
Secretary: Dr. G. A. Smith, Montgomery.
Place: Clarksburg. Time: May 19-21, 1931.

LOCAL

ACADEMY OF MEDICINE OF NORTHERN NEW JERSEY, SECTION ON EYE, EAR, NOSE AND THROAT

Chairman: Dr. J. Wallace Hurff, 86 Washington St., Newark.
Secretary: Dr. Earl LeRoy Wood, 31 Lincoln Park, Newark.
Place: 91 Lincoln Park South. Time: 8:45 p. m., second Monday of each month.

ATLANTA ACADEMY OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

President: Dr. John R. Childs, 45 Edgewood Ave., Atlanta.
Secretary: Dr. William O. Martin, Jr., 384 Peachtree St., Atlanta.
Place: Academy of Medicine, 38 Prescott St., N. E. Time: 8 p. m., last Thursday of each month.

BALTIMORE CITY MEDICAL SOCIETY, SECTION ON OTOLOGY AND LARYNGOLOGY

Chairman: Dr. William R. McKenzie, 11 E. Chase St., Baltimore.
Secretary: Dr. James J. Chisolm, Medical Arts Bldg., Baltimore.
Place: 1211 Cathedral St. Time: 8:30 p. m., last Friday of each month.

CHICAGO LARYNGOLOGICAL AND OTOLOGICAL SOCIETY

President: Dr. George J. Dennis, 25 E. Washnigton St., Chicago.
Secretary-Treasurer: Dr. Austin A. Hayden, 25 E. Washington St., Chicago.
Place: Medical and Dental Arts Bldg., 185 N. Wabash Ave. Time: 6 p. m., first Monday of each month from October to May.

CINCINNATI OTO-LARYNGOLOGICAL SOCIETY

President: Dr. Edward D. King, 707 Race St., Cincinnati.
President-Elect: Dr. M. F. McCarthy, Union Central Bldg., Cincinnati.
Secretary-Treasurer: Dr. Samuel Seltz, Provident Bank Bldg., Cincinnati.
Place: University Club. Time: 6:45 p. m., second Tuesday of each month from October to May.

CLEVELAND ACADEMY OF MEDICINE, SECTION OF OPHTHALMOLOGY AND OTOLARYNGOLOGY

Chairman: Dr. William V. Mullin, 9204 Euclid Ave., Cleveland.
Secretary: Dr. H. C. Rosenberger, 2064 E. 9th St., Cleveland.
Place: Winton Hotel. Time: Fourth Friday of each month.

College of Physicians of Philadelphia, Section on Otolaryngology

Chairman: Dr. Ralph Butler, 2007 Chestnut St., Philadelphia.
Clerk: Dr. Karl M. Houser, 1826 Pine St., Philadelphia.
Place: College of Physicians. Time: 8:30 p. m., third Wednesday of each month from October to June.

Columbus Ophthalmological and Otolaryngological Society

Chairman: Dr. A. M. Hauer, 327 E. State St., Columbus, Ohio.
Secretary-Treasurer: Dr. Albert D. Frost, 681 E. Broad St., Columbus, Ohio.
Time: First Monday of each month.

Dallas Academy of Ophthalmology and Otolaryngology

President: Dr. H. B. Decherd, 1717 Pacific Ave., Dallas, Texas.
Secretary: Dr. W. Mood Knowles, 1717 Pacific Ave., Dallas, Texas.
Place: Dallas Athletic Club. Time: 6 p. m., first Tuesday of each month from October to June. The November, January and March meetings are devoted to clinical work.

Detroit Oto-Laryngological Society

President: Dr. Don A. Cohoe, 13535 Woodward Ave., Detroit.
Secretary-Treasurer: Dr. R. Lee Laird, 513 David Whitney Bldg., Detroit.
Place: Maccabees Bldg. Time: Third Wednesday evening of each month from October to May.

Fort Worth Eye, Ear, Nose and Throat Society

President: Dr. J. J. Richardson, 606 Penn St., Fort Worth, Texas.
Secretary-Treasurer: Dr. R. H. Needham, 1304 Medical Arts Bldg., Fort Worth, Texas.
Place: University Club. Time: 6:30 p. m., first Friday of each month except July and August.

Houston Academy of Medicine, Eye, Ear, Nose and Throat Section

President: Dr. Claude C. Cody, 1306 Walker Ave., Houston, Texas.
Secretary: Dr. J. M. Robinson, Eye, Ear, Nose and Throat Hospital, Houston, Texas.
Place: Medical Arts Bldg., Harris County Medical Society Rooms. Time: 8 p. m., first Thursday of each month from September to June.

Indianapolis Ophthalmological and Oto-Laryngological Society

President: Dr. E. L. Lingeman, 241 N. Pennsylvania St., Indianapolis.
Secretary: Dr. Kenneth L. Craft, Hume-Mansur Bldg., Indianapolis.
Place: University Club. Time: 6:30 p. m., second Thursday of each month from October to May.

Kansas City Society of Ophthalmology and Otolaryngology

President: Dr. A. E. Eubank, Arygle Bldg., Kansas City, Mo.
Secretary: Dr. O. S. Gilliland, Professional Bldg., Kansas City, Mo.
Time: Third Thursday of each month from September to May. The November, January and March meetings are devoted to clinical work.

Long Beach Eye, Ear, Nose and Throat Society

President: Dr. Dean E. Godwin, Security Bldg., Long Beach, Calif.
Secretary-Treasurer: Dr. Ferris Arnold, Security Bldg., Long Beach, Calif.
Place: Pacific Coast Club. Time: Last Wednesday of each month from September to June.

Los Angeles County Medical Society, Section of Ophthalmology and Otolaryngology

President: Dr. Eugene R. Lewis, 727 W. 7th St., Los Angeles.
Secretary-Treasurer: Dr. J. Frank Friesen, 727 W. 7th St., Los Angeles.
Place: California Hospital, assembly room. Time: 8 p. m., first Monday of of each month, May to November, inclusive.

Medical Society of the County of Kings, Section on Otolaryngology

Chairman: Dr. John M. Auwerda, 878 President St., Brooklyn.
Secretary-Treasurer: Dr. Charles R. Weeth, 37 Remsen St., Brooklyn.
Place: Library Bldg., County Society, 1313 Bedford St., Brooklyn.
Time: 9 p. m., second Wednesday of January, March, May and November.

Medical Society of the District of Columbia, Section on Ophthalmology and Oto-Laryngology

Chairman: Dr. James A. Flynn, 1511 Rhode Island Ave., Washington.
Secretary: Dr. E. R. Gookin, Medical Science Bldg., Washington.
Place: 1718 M St., N. W.: Time: 8 p. m., third Friday of each month.

Memphis Society of Ophthalmology and Oto-Laryngology

Chairman: Each member, in alphabetical order.
Secretary: Dr. R. O. Rychener, Exchange Bldg., Memphis, Tenn.
Place: Eye Clinic of Memphis Eye, Ear, Nose and Throat Hospital. Time: 8 p. m., second Tuesday of each month.

The Milwaukee Oto-Ophthalmic Society

President: Edward R. Ryan, 425 E. Water St., Milwaukee.
Secretary-Treasurer: Dr. O. P. Schoofs, 120 E. Wisconsin Ave., Milwaukee.
Place: University Club. Time: 6:30 p. m., third Tuesday of each month.

Nashville Academy of Ophthalmology and Otolaryngology

Chairman: Dr. Hilliard Wood, 700 Church St., Nashville.
Secretary-Treasurer: H. C. Smith, Medical Arts Bldg., Nashville.
Place: St. Thomas Hospital. Time: 8 p. m., third Monday of each month.

New Orleans Ophthalmological and Otological Society

President: Dr. W. R. Buffington, 211 Camp St., New Orleans.
Secretary-Treasurer: Dr. M. F. Meyer, Canal Bank Bldg., New Orleans.
Place: Eye, Ear, Nose and Throat Hospital. Time: January to June and October to January—third Thursday of each month.

New York Academy of Medicine, Section of Laryngology and Rhinology

Chairman: Dr. John M. Loré, 240 West End Ave., New York.
Secretary: Dr. Robert E. Buckley, 2 E. 103d St., New York.
Place: 103d St., and 5th Ave. Time: 8:30 p. m., fourth Wednesday of each month from October to May.

New York Academy of Medicine, Section of Otology

Chairman: Dr. Clarence H. Smith, 2 E. 54th St., New York.
Secretary: Dr. James Garfield Dwyer, 57 W. 57th St., New York.
Place: 103d St. and 5th Ave. Time: Second Friday of each month from October to May.

Omaha and Council Bluffs Ophthalmological and Otolaryngological Society

President: Dr. Charles M. Swab, Medical Arts Bldg., Omaha.
Secretary-Treasurer: Dr. J. C. Davis, 1615 Howard St., Omaha.
Place: Medical Arts Tea Room. Time: 5:15 and 7 p. m., third Wednesday of each month from October to May.

Philadelphia Laryngological Society

President: Dr. Arthur J. Wagers, 1429 Spruce St., Philadelphia.
Secretary: Dr. Herman B. Cohen, 1301 Spruce St., Philadelphia.
Place: College of Physicians. Time: 8:30 p. m., first Tuesday of each month from October to June.

Pittsburgh Otological Society

Chairman: Dr. Watson Marshall, 121 University Pl., Pittsburgh.
Secretary-Treasurer: Dr. Thomas B. McCollough, 121 University Pl., Pittsburgh.

Rochester Eye, Ear, Nose and Throat Society

Chairman: Dr. Clyde Heatly, 11 N. Goodman St., Rochester, N. Y.
Secretary-Treasurer: Dr. John F. Gipner, 53 S. Fitzhugh St., Rochester, N. Y.
Place: Rochester Medical Association, 13 Prince St. Time: 8 p. m., third Monday of each month from October to May.

St. Louis Ear, Nose and Throat Club

Acting President: Senior member of the executive committee: Dr. George E. Hourn, 607 N. Grand Blvd., St. Louis.
Secretary: Dr. Arthur M. Alden, Frisco Bldg., St. Louis.
Place: University Club Bldg. Time: Third Wednesday in February, April, October and December.

San Antonio Ophthalmolo-Oto-Laryngological Society

President: Dr. T. J. Walthall, 728 Main St., San Antonio, Texas.
Secretary-Treasurer: Dr. E. D. Dumas, 425 Medical Arts Bldg., San Antonio, Texas.
Place: Bexar County Medical Library. Time: 8 p. m., first Tuesday of each month from October to May.

San Francisco County Medical Society, Section on Eye, Ear, Nose and Throat

Chairman: Dr. Wilber F. Swett, 693 Sutter St., San Francisco.
Secretary: Dr. Robert Carson Martin, 384 Post St., San Francisco.
Place: Society's Building, 2180 Washington St., San Francisco. Time: Third Tuesday of every month except May, June, July and December.

Spokane Academy of Ophthalmology and Otolaryngology

President: Dr. Paul A. Remington, Old National Bank Bldg., Spokane, Wash.
Secretary: Dr. Louis A. Parsell, Paulsen Medical and Dental Bldg., Spokane, Wash.
Place: Paulsen Medical and Dental Library. Time: 8 p. m., fourth Tuesday of each month except June, July and August.

Syracuse Eye, Ear, Nose and Throat Society

President: Dr. Searle B. Marlow, State Tower Bldg., Syracuse, N. Y.
Secretary-Treasurer: Dr. A. Harry Rubinstein, Medical Arts Bldg., Syracuse, N. Y.
Place: University Club. Time: Second Friday of each month except June, July and August.

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